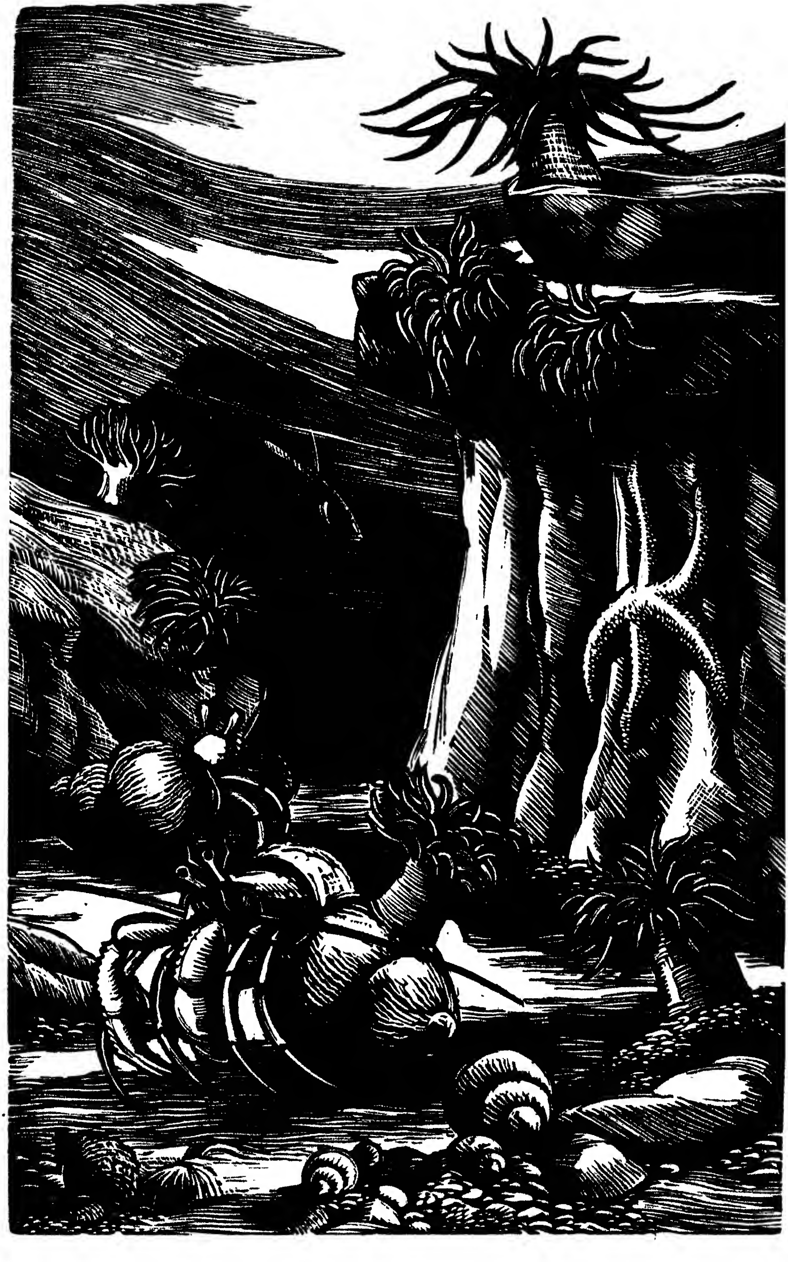
WONDERS OF
NATURAL HISTORY



WONDERS
of
NATURAL HISTORY

by

E. L. GRANT WATSON

illustrated by BARBARA GREG

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'But how if Nature vetoes all
Her commentators? Disenthral
Thy heart. Look round.'

FROM *Clarel*

HERMAN MELVILLE

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INTRODUCTION

The following sketches of animal histories are chosen from among the many examples of life in Nature which must evoke admiration, wonder and, I think, surprise in anyone who looks at all closely at the pattern they present. You may say that life itself must do this for most people, and that is true, but in these cases there are complications of development and association which particularly excite astonishment. Many of the stories I have to tell are derived from papers published in scientific journals which are not easily accessible, and are also drawn from personal observations of animal life both in Europe and Australia.

In each case the creatures are described in their natural environment and are not, as in laboratory experiments, separated from it for the sake of either simplicity or elaboration. The animal, its form, its behaviour, its associates and its whole environment are regarded as comprising a unified and indivisible pattern, and any speculations I have allowed myself to make are the result of what feelings and thoughts this pattern evokes. Such feelings and thoughts cannot, in any case, be ruled out, however much we may strive after objectivity. We see what we can, and what experience teaches us to see. Our surrounding universe is determined by what we have of poverty or riches in ourselves.

E. L. GRANT WATSON

THE BUTTERFLY AND THE ANT

On the grass and thyme-covered cliffs of Devon and Cornwall and on the Cotswolds of Gloucestershire, there is still to be seen by those who look in the right time and in the right localities, one of our rarer English butterflies, The Large Blue (*Nomiades arion*). This little creature which is not so very much larger than the Common Blue, and would scarcely be noticed by any but an observant eye, has a life history of the strangest, and is so peculiarly adapted to the extravagant idiosyncrasies of its fate as to make any simple believer in the evolution of species through adaptation to environment pause and wonder.

The butterfly is to be seen flying during the last week in June and in July; it flutters close to the grass, like other members of its tribe, and the females can be seen depositing their minute eggs on the petals of the wild thyme flowers.

When the little caterpillar emerges from the egg it begins to feed on the downy exterior of the blossoms, and will in time work its way to the base of the petals. Besides its vegetable food it will readily devour any of its fellows that it may meet, and is at this period of its life voraciously cannibalistic. In shape it is like a wood-louse. Like all

other caterpillars it must change its skin as it grows, and for the first two skin-changes it remains feeding on the flower-heads. After the third skin-casting the habit of the caterpillar changes. It becomes restless, drops off the flower-head and begins to walk. It has been described by Captain E. B. Purefoy, who has worked out the history of this insect with great exactitude, as walking as though it wanted something and did not know what. It walks and it walks until by chance it meets an ant. It is a remarkable fact that the eggs are usually laid by the mother insect on tufts of thyme that are growing upon ants' nests.

At the first meeting with the ant, the caterpillar shows no sign of recognising its future fate, but the ant recognises the caterpillar. She will begin at once to stroke and caress the caterpillar with her antennae and feet. Now on the tenth segment of the caterpillar there is a pore which has the power of secreting and exuding a sweet kind of honey-dew. As soon as the ant begins her caresses, the caterpillar exudes a drop of dew, which the ant sucks up. Other ants may come and join in this 'wooing' of the caterpillar, and subsequent milking. Many drops of dew are exuded.

After a time, prompted by some unexplained and mystic sympathy, the caterpillar prepares itself to be carried off. It gives the signal to the ant by assuming a most extraordinary attitude, swelling up the thoracic segments. The ant, on receiving this signal (and it is always the original ant that responds and not the late-comers), gets well astride the caterpillar, and seizes it gently in its jaws, holding it immediately behind the hunched-up thoracic segments. It then sets off at a quick pace, carrying the grub to its nest underground, and deposits it in one of the chambers where the young ant grubs are being nurtured.

From this time on the caterpillar lives on the defenceless, white ant grubs, and, in exchange for this hospitality, it gives to the ants its honey-dew, when with their antennae or their feet they caress the pore on the tenth segment. Experiments have been tried to stimulate this flow by other means than ant caresses. The pore has been gently tickled with the tip of a very fine paint brush. But no response has been made. Only to the touch of the ant is the insect sensitive.

All through the remaining weeks of the summer the caterpillar feeds on the ant larvae, and when autumn comes it hibernates in the underground cell, together with the ants. In the spring it wakes up

again and recommences feeding. In late May or early June it will pupate. For three weeks it will rest in the chrysalis, and at the end of that time it emerges as a butterfly. Its wings are at first unexpanded, mere limp and shrivelled leaves that droop on each side of the body. How unlikely a place—the dark underground of an ant's nest for a butterfly to find itself. And how dangerous one would suppose, for ants will often devour butterflies, springing upon them and pulling them from the grass stems where they sometimes doze. But this butterfly, crumpled, helpless, deep within their own nest, the one-time devourer of their children, is free to crawl through the dark passages up towards the light. Why is it exempt? Why does it not perish? It possesses no longer any seductive honey-pore. Nothing that it can offer as a bribe for its exemption. It has a free passage as far as the ants are concerned, and if it does not lose its way in the dark passages, it wins at last to the light, crawls up a grass stem, and there begins that rhythmical pumping movement which fills the veins of the wings with its pale yellowish-green blood. They expand and hang over the back, folded together. In time the blood hardens, giving to the wings the necessary firmness.

The life history is complete and the butterfly, who, we must presume, is quite unconscious of its cannibalistic childhood and its ant-devouring adolescence, now uncoils its long proboscis preparatory to the innocent sipping of nectar.

How was such a creature evolved? Is it conceivable to imagine such a sequence of adaptations as the result of small continuous variations? Did the honey-pore spring into existence as a mutation? And if so, did the disposition to drop from the food plant and take to a wandering life synchronise with the origin of this mysterious organ? When did the first ant meet the first caterpillar? And did the first caterpillar hunch itself into a convenient shape, to allow the ant to carry it off without too much trouble, or were these habits learnt by practice and perfected through generations of experience? Why does the ant hold its hand, or rather its jaws, and spare the helpless butterfly that under other circumstances it would devour?

Are all these characteristics, so firmly established and so definite, to be explained by calling them fortuitous mutations? Does that really mean anything? Will any of the Classical Theories of Evolution, Neo-Lamarckian or Neo-Darwinian, account for the strange sequence of facts in the life of the Large Blue?

THE CASE OF A SEA SLUG

Sea slugs are brighter coloured and more fantastic in form than those that live upon land. They are to be found in shallow pools when the tide is low, and there are several species which frequent our English seaboard. Many of these have brilliantly coloured papillae or appendages growing from their backs, and in these are found groups of curiously formed stinging-cells, which are believed to function as defensive weapons, and which protect the slugs from the attacks of fishes. It is presumed that the fish snaps at the bright coloured appendages rather than at the more sober-hued vital portion of the mollusc, and that he receives in his mouth a discharge of nettle-cells which will send him away discomforted, and prevent further attack. This is true of only some fish, as there are species, such as the cod, which will devour sea slugs with impunity.

The nettle-cells, or nematocysts, as they are called, have a curious history, and one which might well provoke questions in the mind of any evolutionist who would maintain that the characteristics of living creatures are the results of environmental stimulus or of fortuitous mutations.

When nematocysts were first discovered to be present in the papillae of sea slugs, they at once excited the interest of scientists, for they suggested a definite and close affinity between the *Mollusca* and a

more simple group of organisms, the *Coelenterata*, which include the sea anemones and jelly-fish. It was previously believed that only coelenterates were provided with nematocysts.

The nematocyst is an explosive cell, which, in its discharged condition, is usually a long whip-like shape; in its undischarged condition it is folded within itself, and at the least touch, the turgor produced by the tension of the cell-wall will cause the enfolded nettle-lash to fly out and sting any foreign body which is in the near neighbourhood. Many sea anemones and jelly-fish are provided with these protective cells. Most people have at one time or another been stung by a jelly-fish, and though the nettle-cells in sea anemones are not so poisonous, their thousand-fold tiny barbs are to be felt by anyone who puts his finger in among the open tentacles of any of our seashore polyps. The barbs seem to cling to the skin and hold it. These nettle-cells are believed to be both protective and offensive. They would be, one could suppose, a protection against the attacks of sea slugs which feed upon the otherwise unprotected sea anemones; they also have an offensive function when helping to entangle or poison the prey of the polyps.

The facts of the relation between the coelenterates and the sea slugs, and the part that the stinging cells play in these almost miraculous happenings have been carefully worked out by marine biologists. It has been found that the nematocysts which lie in an unexploded condition in the papillae of the sea slugs, and which are used by them as defensive mechanism against their enemies, have their origin in the coelenterates on which the slugs feed.

Although this much is known, much still remains obscure. How is it that the nematocyst which explodes at the least touch, is *not* exploded by the sea slug in the process of being devoured? How is it that the harsh, saw-like radula of the slug, with which it *tears* its food, does not break the sensitive capsule of the nettle-cell? It has been suggested that the slug, in eating, exudes mucus which prevents the discharge of the nematocysts, but is this sufficient explanation? Why are not the defensive cells discharged on the approach of the slug? They are discharged in some cases, but not in all. Why not? And how is it that the slug is immune from the poison? Mr. O. C. Glaser writes: 'It is truly remarkable that these apparently helpless creatures (the sea slugs) should have selected such a dangerous prey, but since they have, it must be because the danger does not apply to them. Why

it does not, I do not know, but it may well be that for the same reason the nematocyst does not discharge while being eaten.'

Those reasons, whatever they are, remain obscure.

The next mystery is: how is it that the unexploded, and only the unexploded nematocysts, are gathered together from out of the stomach of the slug into narrow ciliated channels, and are swept by the working of the cilia, extremely minute hair-like filaments, up into the tiny pouches which lie near the periphery of the brightly coloured appendages, and how is it that they are there neatly arranged the right way up, in such a manner that they can be discharged against any intruder which threatens the peace of the sea slug? How is such a complicated and highly specialised sequence of events to be accounted for?

But is this really true? the reader will ask. Are you sure of the facts? Surely it is only reasoning, reasonable men who can steal the offensive weapons of weaker creatures to use for their own purposes!

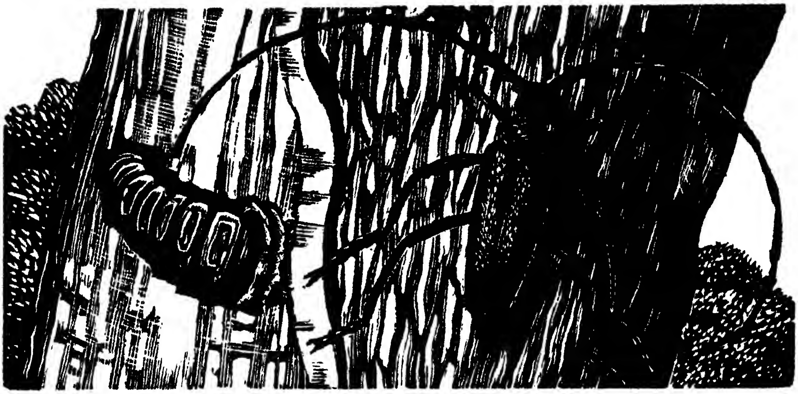
The facts have been most laboriously investigated. G. H. Grosvenor has proved that the nematocysts found in sea slugs and coelenterates are identical in plan and construction and in mode of discharge, and that nematocysts of several distinct types occur in both groups—also that a single type of nematocyst does not occur uniformly throughout any one species of sea slug, but that different individuals of the same species may have quite different nematocysts according to the food. He has also proved that a single individual sea slug may have, within the pouches on the dorsal appendages, nematocysts of several different types, found in distinct groups of coelenterates . . . and also that when it is known on what coelenterates a sea slug has been feeding, then the nematocysts in the two are identical. Also he has proved that sea slugs which feed on animals which have no nematocysts have themselves no nematocysts. He has also demonstrated the ciliated canals which pass from the diverticula in the stomach to the pouches on the dorsal appendages, and he has conclusively proved that the nematocysts in any particular sea slug can be changed after a change of diet.

The facts are established, but the question of how this truly remarkable state of affairs has come about no one has answered, nor has any theorist tried to explain how any such unique combination of characteristics *comes to be evolved.*

When I was a student, Adam Sedgwick was Professor of Zoology

at Cambridge. On one occasion I remember when I was turning over the pages of a zoological textbook, he paused and stood behind me when I chanced to have turned up a picture of Archæopteryx, the winged and feathered reptile of the Triasic period. 'Precipitated!' he said with a characteristic sniff. I was then in my second year and a convinced Evolutionist. I turned to him with what might well have been an enquiring and discomforted look. 'Precipitated,' he repeated. 'We don't say created in our days, it's not the fashion.'

It would need perhaps as wise a man to make the same comment after investigating the case of the sea slug.



WISE WORMS

The larvae of a large number of beetles make their diet exclusively on wood. They live within the trunks of trees, and from the time when as small grubs they penetrated the bark, to the time when, two or three years later, they finally emerge as perfect beetles, they sense nothing of the world beyond the tree-stem through which they monotonously eat their way. If we could follow with an X-ray photograph the winding path of one of these beetle grubs, we would find that it began small, a mere thread, and that it gradually grew wider in diameter as the larva increased in size. The tunnel that the creature had made would be filled up in the track of the advancing grub with the wood-waste which had been excreted; this would be packed tight in one continuous line, filling all the tunnel. Little nourishment can be extracted from wood, and so the beetle larva is forced to eat most of his time. As there is nothing else to do, this is no great hardship.

The larva of the Great Capricorn Beetle spends the greater part of three years inside an oak tree. When it is full grown it is about two and a half inches long and five-eighths of an inch across at the thickest part of the thorax. It is an ivory white, and almost naked except for a few short hairs. It is a segmented, muscular tube with a mouth at one end, with gouging mandibles and strong muscles to drive them, an intestine and an anus. The true legs are vestigial, mere tiny, black

excrescences, and are of no use in walking. The grub moves in its burrow by means of a number of four-sided facets, bristling with rough protuberances, which are placed both ventrally and dorsally on the segments. These are its ambulacra. When the larva wants to progress it expands its hinder ambulacra both on back and belly and contracts the front ones. Having moved forward, it expands the forward ambulacra and contracts the hinder ones. It is only adapted for movement within the tube, and cannot move on a flat surface. This larva has no eyes, it is quite blind. It shows no sign of being able to hear. It is quite indifferent to smell. It can presumably taste its woody food, but can find little variety during its three years of oak diet. It is sensible to touch. Compared with the larvae of other insects which live in a less secluded retreat it appears strangely degenerate. The organs of sense are almost entirely lacking and the legs are mere vestiges.

It is not difficult to suppose that this creature has taken on its specialised and degenerate form in response to its environment; as the generations have passed, the senses, which were of no use within the dark silence of the tree, have degenerated, and the legs, designed in the first place to crawling over a surface, have withered and been replaced by the ambulacra on back and belly. This, on the face of it, is not an unreasonable supposition, but if we examine further the life habits of this grub, we will find qualities upon which its survival is altogether dependent and which it is hard to imagine as being derived from a purely mechanistic response to environment.

During the greater part of the larval life, the grub eats its winding passage through the hard heart of the oak; it never comes near to the surface of the bark, but keeps safely remote from woodpeckers and other insect-eating birds. If it were led by chance only, it would, in the long course of its twistings and turnings in that dark, silent burrow, be likely to come to the surface more than once. A guiding instinct keeps it safe, buried in the interior of the stem. When, however, the time draws near for the larva to change into its pupal state, it eats its way to the very margin of the bark, and will sometimes eat its way right through to the outside. This is its time of greatest danger, and it runs a very real risk of being eaten by a woodpecker. Why does it do this? For the good reason that the beetle, after the metamorphosis, is incapable of eating its way through hard wood. If the pupa were to be formed anywhere but at the extreme margin of the bark, the emerged beetle would die imprisoned.

The behaviour of the *senseless* grub in preparing for the pupal state is worth noticing. When it has eaten its way close to the bark, it makes a pupal-chamber three to four inches in length, about an inch wide and three-fifths of an inch deep. The sides of this chamber it rasps with its mandibles, making a kind of velvety substance from the torn fibre, which will afford soft-lying for the tender pupa. Across the outward-pointing end of the cells it makes, from an excretion of its stomach, which hardens as it dries, a chalky shield, which serves as a protection to the otherwise unguarded end. Having made these preparations for the safety and comfort of the pupa, the grub, whose sole experience hitherto has been that of eating in a dark and silent tunnel, has the unvarying good sense to lay itself down with its head outwards towards the bark. The grub, which is soft and flexible, can, of course, turn easily in any direction within the cell, but the emerged beetle cannot move in any direction except that in which it lies. The beetle is encased in hard plates, and provided with stiff wing-cases, which cannot bend. Should the grub make a mistake and lie head inwards, the beetle, when its metamorphosis were completed, would be unable to turn round and would perish entombed within the cell. The grub never does make a mistake; it always lays itself down the right way, so that when the beetle emerges it has merely to push aside the chalky shield, which is easily dislodged from inside by its mandibles, and walk out into the world of sunshine which it can now see for the first time.

No one can imagine that this blind and deaf, worm-like grub can have any knowledge of its future life as a beetle; nor can it have any knowledge of the outside world. Is its behaviour the result of racial experience, and does this experience find its being and expression in the degenerate sense organs? Does the larva perceive, in its darkness and deafness and dumbness and scentlessness, which end of the cell is which, and so place itself, as the result of stimuli acting upon those sense memories? The thought is not unthinkable, though it is not one which easily commends itself as probable. If we follow this line of supposition, we must imagine earlier generations some of whom made mistakes, and who lay down for their pupal sleep with their heads in the wrong direction. On the law of chances, fifty per cent would lie one way, fifty per cent would lie the other. Fifty per cent would perish, entombed and unable to emerge. Those which did emerge, we would have to suppose, would pass on a tendency to their offspring to lie

down in the pupal chamber with their heads outward. And so in the course of numberless generations, so the argument must run, the inherited habit would become an unerring instinct in the grub. This thought, I repeat, is not unthinkable, and it affords a line of reasoning, which is held to be true by many biologists. The only alternative solution would be to postulate a life inspiration, a life wisdom, within the grub, which is innate and not acquired.

A PESSIMIST AND AN OPTIMIST

There is a lady-bird which is greatly attracted by the scent of the nectar of flowers, and is so fashioned as to be unable to satisfy its desire to taste what its sense of smell proclaims as so attractive. This small beetle with its short legs and flat, tortoise-shaped body, climbs laboriously the stem of the flower-head, it negotiates the sepals, often in a difficult and upside-down position, and at length reaches the petals, at whose base the nectar lies. After taking up its position, grasping a petal, it puts its mouth in the direction of one of the honey cups which are situated on either side of the petal-base. Unfortunately for the lady-bird, it has but a short tongue, and one not adapted to thrusting into narrow places. In its effort to reach the nectar it bites with its mandibles. The petal falls off, and the beetle with it, to the ground. Undeterred by this failure, it proceeds to creep up the flower-stem once again, and again makes its way on to a petal, again thrusts its head forward and bites, and again falls to the ground. Once more, after it has recovered from the shock of the fall, it hopefully repeats the process. The behaviour of this little lady-bird has been described by Dr. Herman Müller in *Die Befruchtung der Blumen durch Insekten.* It never learns by experience and never gets a taste of the sweet-smelling nectar.

If this lady-bird could formulate a philosophy from the results of its experience, it would be in agreement with Thomas Hardy, that 'life offers to deny'. The disharmonies between its desires and its means of gratifying them are obvious; it is a natural pessimist, a soul on whom Providence does not smile.

In contrast to such an unfortunate case there are creatures whose adaptation to their environment is so perfect and so complex that they would appear the very darlings of the gods, and to live in the best of all possible worlds. Not only are the details of their lives arranged with a happy and perfect precision, but they are endowed with a prophetic knowledge as to the needs and educational requirements of their unborn offspring, and are possessed also of an intuitive wisdom which can correctly determine problems before which our human science still falters.

Such a creature is *Eumenes amedei*, a small wasp-like hymenopterian which inhabits northern Africa and southern Europe. In early summer when the sun heat is already powerful, the *Eumenes* emerges from the pupal state. She is an elegant insect of yellow and black bands. When stimulated by the sun's heat, her antennae, wings and legs are in vibrant motion, as though the life in her were too intense to be sustained without this quivering response to the elements of air and fire, of which she seems an embodied expression.

Soon after she has mated, the female begins to prepare a house in which her young can develop and be sheltered, and in which sufficient food can be stored. She chooses an exposed and sunny situation, usually on a rock or wall, and there begins to build. She first erects a circular fence of small stones and mortar, the mortar being made from dry, flinty dust mixed with her own saliva. The stones are chosen with considerable care, flint being preferred to limestone, and the fragments selected are all much of the same size. J. H. Fabre, in describing the habits of this insect, dwells on the meticulous manner in which the *Eumenes* chooses the most polished quartz fragments for her buildings, and suggests that she is not indifferent to the aesthetic effect of her handiwork.

As the wall grows higher, the builder slopes it towards the centre, and so makes the curve of a dome, which, when finished, is the size of a small cherry. A hole is left at the top, and on this is built a funnelled mouthpiece of cement. The next task is to collect the food-supply for the future grub, which is to hatch from the egg of the *Eumenes*. This

consists of a collection of small caterpillars of about half an inch in length; these are always of the same kind, palish-green and covered with white hairs. These caterpillars are partially paralysed by the sting of the *Eumenes* and unable to make any violent efforts at escape. They are stored on the floor of the cell. Since they remain alive, they will keep fresh till such time as the grub of the *Eumenes* is ready to eat them. If they were killed outright their flesh would soon become putrid or would wither and dry. The young grub requires the best of fresh meat. When the cell is sufficiently stocked, the egg is laid, a single egg in each cell, and the mouthpiece at the top of the cell is closed with a cement plug, and in the cement is set a single pebble.

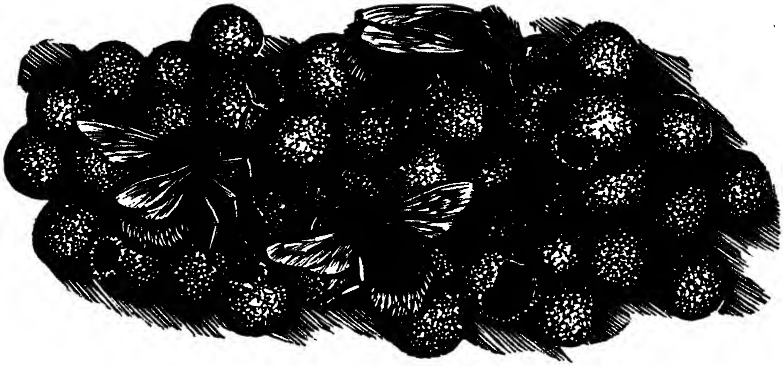
The egg is not laid in amongst the caterpillars, nor upon one of them, as in the case of other allied genera. These caterpillars are only partially paralysed, and can still move their claws and can champ with their jaws. Should one of them feel the nibblings of a tiny grub it would doubtless writhe about, and would probably injure the tender infant for whose benefit all this genius of instinctive forethought is exercised. Both the egg and the grub must be protected, and to this end the egg is suspended to a tiny thread of silk fastened to the roof. However much the caterpillars may wriggle and writhe, they cannot come near it.

When the grub emerges from the egg, it devours its egg-shell, then spins for itself a tiny, silky ribbon-sheath in which it is enfolded tail uppermost and with head hanging down. In this retreat it is suspended above the pile of living food. It can lower itself sufficiently far to nibble at the caterpillars. If they stir too violently, it can withdraw into its silken sheath, and wait awhile till the commotion has subsided, then later, when the caterpillars are grown quieter, descend again to its meal. As the grub grows in size and strength, it becomes bolder; the silken retreat is no longer required; it can venture down and live at its ease amongst what remains of the food store.

In all these ways, the *Eumenes* is singularly well adapted to the conditions of its life, but these are not all. The stone and cement cells that the mother *Eumenes* builds are not always stored with the same wealth of caterpillars. Some cells contain five caterpillars, and some ten. The females of the imago *Eumenes* are larger than the males, therefore they need a larger supply of food—in fact, just twice as much. From out of the well-stocked cells emerge females, from those half as well stored emerge the smaller males. Now the cells are

stocked before the eggs are laid, and it is a generally accepted belief amongst biologists that the egg bears within itself the sex valency which will dominate in the developed creature. The maleness or femaleness of the egg is already determined at the time that it is laid. The female eggs are laid in the well-stocked cells, and the male eggs in less well-stocked cells. How does the *Eumenes* know the future sex of her egg? How is it that she never makes a mistake? Can a theory of chances play a part in this problem? If nothing is logically arranged, and all variations occur without any relation to a foreseen object, how is this clear and unerring adaptation to what is invisible and unmeasurable acquired? A question for behaviourists to answer.

Let us compare the fates of the *Eumenes* and the lady-bird. The one is endowed with the most perfect instincts for both building and hunting. The caterpillars on which she feeds her offspring are plentiful and easily paralysed, and obligingly remain alive until such time as they shall be eaten. Her grubs are endowed with a wisdom and caution equal to her own foresightedness, and over and above all this, the inspiration of her instinct tells her the future sex of her eggs, so that she may provide rightly and with economy for the needs of her sons and daughters. She lives in a world perfectly adapted to her gay, ruthless, vibrant nature. How different from the slow, tortoise-shaped lady-bird, whose appreciative senses tell her of the nectar she can never reach, and whose fate it is to fall clinging to the petal she herself has detached!



HUMBLE-BEES AND THEIR DOUBLES

The queen humble-bee, who is the builder and guardian of her household, and who is to become the mother of her own large family, is raised in her mother's nest in company with many other daughter queens in July or August. This rearing of the queens is the final effort of the parent colony, and as soon as the young queens are able to fly and are mated, they disperse and find for themselves suitable places for hibernation. They make small burrows in situations that are cool and dry, preferring a north aspect to a south, for they do not wish to be warmed into wakefulness too early in the following year. For eight or nine months they remain quiescent, and do not emerge much before mid-May.

The large black humble-bee with the red tail, *Bombex lapidarius*, is one of the commonest and most handsome of English bees; her life history, though it differs in details from that of other members of the genus, as she herself differs in physical appearance and size, is very much the same as that of all other humble-bees. As soon as she has come out from her winter retreat, she looks about for a nesting-place, and usually chooses the deserted nest of a field-mouse or vole. This is by preference underground or under a large stone or in a crevice of a loosely-built wall. Her first task is to arrange the moss and grass of the old nest into a spherical mass with a cavity left for herself in

the centre, about an inch from side to side and of about five-eighths of an inch in height. On the floor of this cavity she deposits a lump of pollen-paste, that she has collected on the shanks of her hind legs. This she moistens with honey and fastens to the floor; it is to be the foundation of the cell in which her young will be enclosed, and is also to serve as their food-store. Around it, and above, she builds a wall of wax, and closes the cell as soon as she has laid her first batch of eggs. She now sits upon them night and day to warm them with her body, only leaving the nest to get food, and soon she builds a waxen honey-pot near the mouth of the nest, in such a position that she can reach forward and sip the honey while she is hatching the eggs or brooding her young.

The eggs hatch into maggot-like, hairless larvae four days after they are laid. They are completely enclosed within the communal cell, in which they are free to mix together. For food they eat their bed of pollen and honey. As they grow older, the mother feeds them with a liquid of the same mixture which she injects through the wall of the cell. She also adds a thicker paste of pollen to the foundation. The grubs grow very rapidly, and, as they grow, the walls of the cell, which are always being added to, take on the shapes of the larvae which are contained within it. At seven days old they are full grown, and begin to spin their cocoons. These stand upright side by side, ten or twelve, or sometimes more in number. They do not form a flat-topped cluster, as might at first be supposed, but those at the sides stand higher than those in the middle, so that a median groove is formed. In this groove the mother bee can sit. She presses her body close to the cocoons to warm them, and stretches out her abdomen to its extreme length. Her outstretched legs clasp the cocoons on either side. Here she remains facing her honey-pot, and from time to time taking a sip to warm and strengthen her. After a period of rest, the larvae change to pupae, and on the twenty-second or twenty-third day after the eggs were laid, the young bees emerge. This first brood are all workers, considerably smaller than the queen. Like hive-bee workers they are capable of laying eggs, but these eggs will only produce drones.

For the first few hours these newly emerged bees nestle around the body of their mother. They are only about half her size, and seem indeed like children. They soon get to work however. Within three days they will be out and collecting pollen and honey with which to feed

the new broods, which are already developing, for as soon as the first family of grubs are pupated, a further batch of eggs has been laid, and other batches follow at intervals of every two or three days. The workers now tend the growing families, and the original nest has to be enlarged to make room for the several batches of grubs. The queen, at this later stage of the family development, will often give up outdoor occupations such as collecting honey and pollen, and will remain altogether within the nest, attending to her maternal duties, and laying, at the height of the season, a batch of eggs a day. In July the queen will begin laying eggs which will produce drones and queens. The drones when they hatch are very similar in size and appearance to the workers. They have, however, a sweet and pungent scent, which it is supposed is agreeable to the queens. The young males leave the nest as soon as they are able to fly, and do not return. The young queens, although they may leave the nest for short flights, do not abandon it until they are mated. The old queen becomes less fertile as her days advance, she loses her hair and her wings are frayed and tattered. As the drones and the young queens depart, the workers dwindle, the comb becomes mouldy, and finally the queen dies. Her life history is completed.

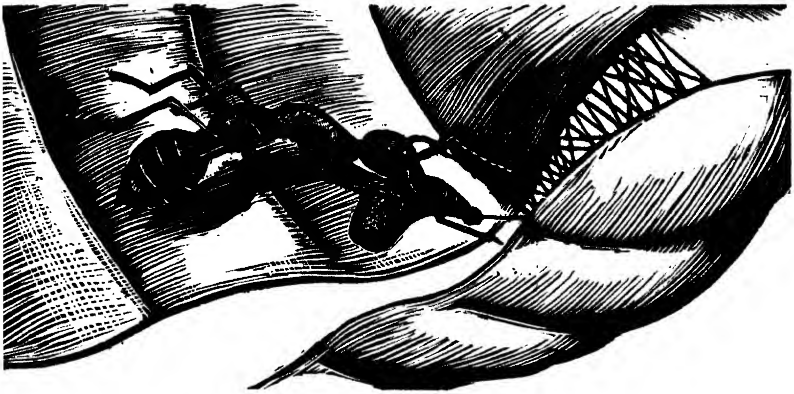
Upon several species of humble-bees there are parasitic bees of almost identical appearance, and it is a remarkable fact that the parasitic species in each case should so closely resemble the creature that it exploits. There is some disagreement amongst authorities as to whether the *Psithyrus* is always parasitic and is not sometimes commensal, living in the nest of the *Bombi,* and contributing in some sort towards its welfare. However this may be in some uncertain cases, there appears to be no doubt that the species *Psithyrus rupestis* is definitely parasitic on *Bombex lapidarius,* whom she so closely resembles. The hind legs of the queen are hairy and are not adapted to the collecting of pollen, and the wings are slightly darker in the case of the *Psithyrus.* She is a slower flier, and the skin of the abdomen is much thicker and harder than that of the *Bombex.* The segments of the abdomen lap tightly over one another. In every other respect she would appear to be the double of her victim. So, too, does the *Psithyrus* resemble her host in every case where she lives in close association with a *Bombex.*

The *Psithyrus* queen enters the nest of her victims at about the time when the first batch of workers are emerging, or shortly after they

have emerged. Her behaviour is, at first, inoffensive, and even deferential. Should she meet the *Bombex* queen, and the latter should threaten her, she will retreat, lifting a leg in protest, and will then hide in the nesting material. As time passes the workers cease to show any hostility and even the queen grows accustomed to her presence. Mr. F. W. L. Sladen, in his book on the humble-bee, gives a vivid account of how the disposition of the *Bombex* queen becomes affected by the presence of her enemy. 'The interest and pleasure in her brood seems less, and so depressed is she that one can fancy she has a presentiment of the fate that awaits her.' At the time when the *Psithyrus* is ready to lay her eggs, comes the crisis. It is then that the rival queens fight. The *Bombex* appears never to have any chance of victory over her better armed adversary. Her thin-skinned and less closely-jointed abdomen is pierced by the sting of the *Psithyrus*, she becomes paralysed and dies, and her dead body is torn in pieces. The victor now lays her eggs, and the grubs which result are fed and tended by the *Bombex* workers. Only drone and queen *Psithyrus* are produced; this genus has no need of workers, since the young grubs throughout their development are fed by the workers of their victims. It naturally follows that no young queen *Bombi* are ever produced in the nests infested by *Psithyrus rupestis*, and it is obvious that the *Bombex*, who is the original founder of the nest, and whose children are enslaved, is ruthlessly exploited by the usurper bee that so closely resembles her. Not only in the case of *lapidarius* and *rupestis* is this resemblance evident, but in every case where a *Bombex* is victimised by a *Psithyrus*. The latter are always slightly better armed both for offence and defence, so that the issue of the struggle is never in doubt.

Curious as is the close resemblance between the parasite and victim in each case, there is a yet more remarkable phenomenon presented by the presence of other insects which make their homes in the nests of the *Bombex*. At the base of each nest there accumulates a certain amount of rubbish, fragments of moss, and broken pieces of wax and spilt bee-bread. In amongst this rubbish, underneath the true nest, are usually to be found the larvae of hover-flies. These larvae do not do any harm to either the *Bombex* or the *Psithyrus*, who inhabit the space above their heads. They live their larval-lives of offal-eating, and complete their metamorphosis, emerging into typical hover-flies. The significant fact is, that these hover-flies mimic in the imago phase the species of *Bombex* in whose nest they have been commensal. Each

species of hover-fly peculiar to each separate and differing species of *Bombex*, mimics that *Bombex*. I say mimics, but that probably is the wrong word. All we can safely say is: that whether it be *Bombex* species, *Psithyrus* species, or hover-fly species, all these living in the same nest have a close resemblance. It is as though some influence of the habitat or some influence of contiguity were at work, making these three different insects take on the same colour and form pattern. Is the *Bombex*, who is in the first place responsible for the nest, responsible for the influence which so affects the *Psithyrus* and the hover-fly?



INSTINCT AND INTELLIGENCE

There is an ichneumon wasp whose maternal instinct bids it to seek for wood-boring grubs in which to lay its eggs. These grubs are boring larvae and live in the interior of trees. Sometimes they venture as near to the surface of the bark as an inch or three-quarters of an inch. They do not come to the surface, and there is no visible sign on the bark that they are lurking beneath. The ichneumon wasp knows, by some mysterious sense, where these grubs are located. With an unerring instinct she chooses the right spot, settles herself firmly with legs straddled, and bores with her long slender ovipositor into the hard wood of the tree. The ovipositor is but a hair's thickness, yet with this fragile instrument the insect is able to bore through an inch of wood and, what appears most wonderful, she chooses the one spot where she will find a grub in which to deposit her egg. By screwing and twisting movements this perforating operation is effected. It takes an hour of concentrated effort.

This creature offers an example of behaviour prompted by what has been called instinctive knowledge. Certainly the ichneumon behaves as if she knew that the grub was there and was vulnerable to the attack of her ovipositor. Whether she *knows* in any sense comparable to human knowledge it is impossible to say, though it would seem most probable that she is not conscious of what she does not see. All

that we can say is, that she behaves as though she knew. Her actions, which are so perfect and precise, she does not learn from experience. The faculty is innate and adapted to her requirements.

Other examples of instinct which suggest a 'knowledge' which is beyond the function of intelligence are provided by certain Indian butterflies, which not only lay their eggs on the correct food-stuff, as most other butterflies and moths do, but which will not lay on any which is not frequented by a particular species of ant, which ants have the habit of tending the caterpillars of these butterflies and protecting them from enemies. The butterfly behaves, as already described in the first chapter, as if she knew that the caterpillars which will emerge from her eggs will be tended and cared for by the ants, and so selects the trees where the ants inhabit. It is almost impossible to believe that she has such conscious knowledge. As in the case of the ichneumon her behaviour is innate, and not acquired by experience, yet if we were to measure this behaviour by human values, we would have to assign to her both a zoological and botanical knowledge. The butterfly selects both the correct tree and the correct species of ant.

Major R. W. G. Hingston has described the above two examples, and many others, in his fascinating book, *Problems of Instinct and Intelligence*, and although he admits that many insects are governed almost entirely by instinct, he contends that rudiments of intelligence, comparable to human intelligence, are to be found amongst ants, wasps, and other insects. Particularly he emphasises the intelligence of ants. Of ants there are a vast number of species, and the behaviour of each species is peculiar and elaborate; the examples chosen are from different species. The reader will judge for himself whether we have the right to apply the term intelligence to creatures which behave in such a manner.

A hunting ant, if she meets an insect such as a beetle, which is too big for her to capture alone, will grip it by a leg and endeavour to hold it down. Other ants will soon realise that a struggle is taking place and will hurry to assist their sister ant. They spread themselves round the beetle, and will seize on every projecting part, legs, antennae, wing-cases. They will pull at and stretch their victim in every direction. A few ants will gather to hold a small insect, and larger numbers for larger creatures. They continue to pull and stretch till their capture is dead. Next they have to transport their kill to the nest.

This is done by a smaller number of ants than was needed for the killing. As many of these ants live in trees, the burden must be lifted. This lifting is effected by a larger number of ants dragging from above and a smaller number pushing and directing from underneath. If human beings were to attempt a proportional task, they could not devise a better method.

Many ants find satisfaction in sipping the excretions of caterpillars, aphides and tree-bugs. They stroke these insects to excite the ejection of a drop of fluid, and it may justly be said that they milk them as human beings milk cows and goats. They guard these juice-producing insects as men guard cattle, they also herd them into special places, and sometimes into enclosures which they have built for them. Major Hingston describes how one particular species of ant will build sheds made of pieces of grass, interwoven with silk for the enclosure of their cattle, and he describes how once he found one of these sheds damaged and the cattle escaping. 'Four ants went after the stray-aways, got below them and cut them off. They probed them with their antennae, bit them with their jaws, by applying force compelled them to turn, then drove them with gentle prods back into the damaged shed. They got them in, guarded the opening, and later in the day repaired the hole.' Major Hingston contends that this behaviour was similar in kind to that which we attribute to intelligence amongst men. Other ants herd caterpillars into special reserves, and not only keep them there for milking, but drive them out to pasture every day. As an instance of another kind of intelligence, there are ants which prey on caterpillars, which defend themselves by emitting a liquid from their spines. In this case the liquid is offensive to the ants. As soon as the spine is touched the caterpillar emits the offensive fluid. The ant holds a bit of dry earth to the drop. The fluid is absorbed. The ant bites at the caterpillar. More fluid is emitted, and again it is mopped up. The actions are repeated until the caterpillar is exhausted and overpowered.

Certain tree-nesting ants make their nest of leaves whose edges have to be drawn together and then fastened. The edge of one leaf is gripped with the mandibles, the edge of the other by the hind legs. The ant pulls, and the leaves come together. If the leaves happen to diverge far apart, a row of ants will grip the two leaves where they are close together, and chains of ants, clinging to each other, will link the edges where a larger space intervenes. The pulling is done as by a tug-

of-war team, in regular rhythm. As the leaves come together, the ants adjust themselves to the new conditions.

Now follows what is the most remarkable feature of this nest building, an action in which instinct and what, from analogy, would seem like intelligence, are merged. The leaves have to be sewn together. The mature ant has no silk, but the larval ant is provided with the power of producing a silken thread for the spinning of its cocoon. The ants seize on their larvae, and holding them in their mouths, carry them backwards and forwards between the leaf edges, and in this way sew the leaves together. In each case the larva co-operates with the ant, and bends its head to the leaf-edge as the ant lowers it into a convenient position. This work will continue for hours and days, and when one larva has used up all its silk, another is brought.

The behaviour of these ants in the building of their nest may certainly be compared with human intelligent behaviour, but what about the behaviour of the grub? If we are to complete the analogy with human actions, then we should have to suppose human beings engaged on a complicated mechanical construction, for the completion of which the assistance of new-born infants is necessary. These new-born infants, who have no knowledge or experience of the world, would have to co-operate with seeming intelligence. Is such a state of affairs conceivable? Is it conceivable that the ant grub has any intelligent co-operation? If the acts of the grub are instinctive, what precisely differentiates them from the acts of the adult ants? Can we indeed say so confidently, as does Major Hingston, that the ants behave with an intelligence comparable with human intelligence? Would it not be safer to hedge a little and merely say that they behave *as if* they were intelligent, and so remain uncommitted but vastly astonished at the mysterious and so-far unexplained phenomena of their activities.

VICTIMS OF NECESSITY

The aboriginal tribesmen of the upper reaches of the Murchison and Gascoyne rivers are thin-limbed, wiry little men, who live the nomadic life of hunters, roaming in their never-ceasing search for food over vast arid plateaux of malee and mulga scrub. The rivers in this part of north-west Australia, though they are marked on the maps, are for the greater portion of the year, and often for several years running, little more than dry ditches, with here and there pools of stagnant water. To these pools all the creatures of the neighbourhood, from the aboriginal inhabitants to the tiniest marsupial mice, come to drink. They are the centres of life, and are only rivalled by the occasional water-holes of the upland plains; these latter are often little more than mere clefts in the rock, sometimes no more than a yard in width, but infinitely precious for the three or four inches of water, which even in the driest weather comes seeping from some hidden spring.

In this semi-desert region, where the rainfall is so occasional and irregular as to be absent for as long as nine or twelve months, the plants and animals that survive have to adapt themselves to the strangest, often most uncomfortable-seeming manners of life. It would appear that the country has changed from what at one time must have been more congenial conditions, and that these animals

and plants, through countless generations, have adapted themselves to the highly modified forms which persist today. In this desert country, they are the victims of their necessity, and are often transformed in the queerest manner from their more normal types, in order to be able to sustain life at all.

There are plants which put forth only a few, small, hairy leaves, which appear most insignificant, and would hardly be noticed by any but the practised eye of a native. Small as their growth is above the surface, they possess enormous roots, and although the leaves stretch but four inches above the soil, their roots are bigger than footballs, and are full of water, reservoirs to be drawn upon during the almost continuous dry weather. These are eagerly sought by the natives, and when found, dug up and split open. And there are plants which possess roots which are shaped like long strings of sausages, ten to eighteen feet long. These the natives will dig for, and hang them on trees, that the water that is stored in them may run out. By such means the native Australian can augment the small supply available from pools and water-holes.

There are also animals which store water during the short moist periods, and are then compelled to hide in the ground, where they must wait till they are again released by another shower, six months or a year hence. A toad is an animal that one would not expect to meet in the middle of an arid, granite plain, for toads are creatures we are accustomed to finding in marshes or ponds, but there is a toad and a large one, a good six inches across, who is to be found on the upland plains of the Australian bush. This creature is indeed a victim of necessity, and is constrained to a completely passive existence for the greater portion of its life. When the rains fall, it comes out of its hole and rejoices for a short week or so. It mates and lays its eggs in the shallow puddles, it croaks all night long as though it were trying to pretend it was in a marsh, and then, as the rains cease and the pools begin to dry up, it fills itself to the fullest extent with water. It has specially developed lymph-sacs on each side of the body and encompassing the fore- and hind-limbs. These it fills to the uttermost of their inflation, so that it is swollen to twice its size; it then scratches itself a hole in the mud of the drying pool. This mud is, a few days later, sun-baked into hard soil, indistinguishable to any but the practised scent from any other portion of the dry, dusty earth. Here, baked-in, the toad must stay for months, living its own passive life,

thinking its own imprisoned thoughts, and subsisting on the water stored in its body. It constitutes a small sphere of moisture under the surface, and only the highly developed sense of smell of an aborigine is able to scent it out.

I have seen young native girls and young women, sniffing the ground, and, at the right places, scratching with their digging-sticks, and unearthing the toads, who, when found, were ruthlessly squeezed of their moisture into expectant and, I hope, appreciative mouths.

Toads are not the only animals who store moisture. There are species of ants, living in the same dry regions, who store honey in their bodies, and this comes to much the same thing as storing water. Certain individuals amongst the ant community are selected to function as reservoirs. Cells are built for them deep underground, and, confined to these cells, they are pumped as full of honey as they can hold. The worker ants collect the honey during the short period when rain is falling and flowers are blooming; this they swallow into their own stomachs and carry to the honey ants. They bring it up out of their own stomachs and force it down the throats of the honey ants. The worker ant has an abdomen about the size of a small pea, but the honey ant's abdomen is often swollen to the size of a large grape. The skin is very thin and stretched and quite transparent, and the abdomen is distended to such an enormous extent that the ant is quite unable to walk. It lies in the seclusion of its cell, a mere living honey tank. When the dry weather comes and the flowers are all dried to powder, and no more honey is available, then, when the active members of the ant community are feeling the pangs of hunger and thirst, they come and tickle this helpless prisoner under the chin. It must then regurgitate part of the store, and so the community is fed.

The natives, who miss very little which is eatable in the bush, do not neglect the honey ants, which supply their one form of confectionery. The children dig for them, and hard work it is, for the cells in which these reservoir ants are confined are always placed deep in the earth, eighteen to twenty-four inches down in hard, dry soil. When the children find the ants, they bite off the luscious grape-shaped abdomens. This may seem a little barbarous and crude to people like ourselves who can so easily obtain ice-creams and chocolates, but where there is no sugar and very little honey to be come by, an inflated ant with a strong honey taste and a slight formic-acid flavouring is not to be despised.

There is another little creature who has gone to extreme lengths to adapt himself to the arid nature of his surroundings. A small lizard about six inches long has been given the rather pretentious name of Mountain Devil. This name is not given on account of size or wickedness, nor even on account of living in the mountains, for these lizards live equally well on the plains, where I have mostly met them; but they are named on account of their peculiar shape, which is all spines and sharp protrusions. If this lizard were sixty feet long instead of six inches, then he might be a devil worthy of his name, but he is an innocent and harmless little creature, who cannot even run fast, but walks at a slow, dignified pace. What is remarkable about him is that he does not need to drink. He lives in regions where there is no water, and he eats small black ants which contain very little of a soft or juicy nature under their chitinous shells. He gets his moisture through his skin. He catches the dew. For this reason it is necessary for him to have as large a skin area in proportion to his content as possible. The many spikes and protuberances give him this large skin area, and with this he catches the small dew which falls at night. The whole skin is absorbent, as can easily be demonstrated. While I was in the bush, I had three of these mountain devils tied to one of the guy-ropes of my tent, and often amused myself by putting a drop of water on one or other of their backs. The drop disappeared as if into blotting paper. This is how these little creatures drink. They need not seek for water or take it in at their mouths.

SUN-WORSHIPPERS

The Gascoyne river, which is shown large upon the map of Western Australia, as though it were a considerable water course, is often for months on end a dry, gravel-strewn bed, with pools of stagnant water marking its course. The surrounding country in the neighbourhood of Carnarvon is arid steppe or semi-desert, and these pools, which survive, become, during the dry season, centres for animal and vegetable life. The stagnant waters contain fish of the most unexpected character, such as sharks and sword-fish. These sea monsters have come inland during the wet season when the river is full of water, and are now left to take their chance of life till the next rains. I have seen the snouts of sword-fish and saw-fish decorating the walls of farm-houses a hundred and fifty miles inland. To these pools come all the animals in the neighbourhood to drink. Kangaroos, wallabies, boody-rats, bandicoots, and rats and mice are all to be seen creeping, in the twilight, out from the bushes that surround the pools. Besides the usual undergrowth there are frequent groves of tall gum-trees that mark the river's course.

The eucalyptus gums, which sometimes grow to great heights, are each possessed by their own groups of animal populations. One has but to lie in the shade and look up to see the tree-lizards clinging close to the smooth, sleek-barked branches. There are tree-mice also and

birds of various kinds, but the insects are of course the most numerous. When the gums are in flower, and they do not flower every year but only occasionally, the pink and red blossoms are swarmed about, not only by all kinds and sizes of hymenopterans, but by many sun-flying beetles and butterflies. Huge buprestids, whose bronze electra are two inches in length, and lesser ones of burnished green are to be seen high up, soaring around the flower heads. These most beautiful of all beetles are difficult to come at, as they only fly near the extreme tops of the branches. To collect them I have been forced to the vandalism of cutting down one of these magnificent trees. It came crashing to earth, and with its pink and red blossoms came many of the insects which were drinking their nectar. Not only on the flowers are creatures of interest to be found. There are hundreds of species which live under the loose folds of bark: gekko lizards of several kinds, centipedes of all shapes and sizes, some as long as nine inches, orange-coloured and dangerous, with a very poisonous bite, also scorpions, wood-lice and spiders galore, and hundreds of beetles, round as boot-buttons, from the size of a pin's head to a good inch in diameter, and numberless others of different shapes and kinds—all these are to be found under the bark. But the insects which are most noticeable of all, even more noticeable than the thousands of biting and stinging ants, are the cicadas. These fill the air with their tremendous song, so that the whole earth and all the air vibrates in response to their music. The greatest and the most beautiful of these is a brown, yellow and black insect of three full inches in length, and of four and a half inches across the expanded wings. This creature is as large as a small bird and flies as swiftly. On a hot day in the dry season there may well be several hundreds of them singing among the branches of one large tree.

The cicada is a drinker of the tree's sap. It has a sharp, sucking beak which it thrusts through the bark of the twigs down to the layer between bark and stem, and while it draws into itself the sweet sap of the tree, it sings. This singing is a harsh, jarring sound when heard close by, but when the insects are distant in the tree-tops and are pouring out that volume of unchecked ecstasy, then it seems that they are expressing in no ambiguous tones their appreciation for the sap they are imbibing, and their delight in the hot sunlight which gives them life. They create a continuous stream of sound which seems, while one listens, to form into a living curtain of gently vary-

ing notes, enfolding the tree, a curtain which blows to and fro with the moving gusts of air, and which is strangely expressive of the heat and the brilliance, which is so mildly tempered by the blue-green leaves of the eucalyptus. All through the hours of sunlight they feed and sing, and though many other insects respond to the sun and become torpid in shadow, the cicada, more than any other creature, appears both in shape and sound to be a direct expression of the sun's heat. Its body is of a dry, brittle consistence, and is full of air-spaces; these are resonators to the sound box, which is situated just posterior to the attachment of the hind pair of wings. By the opening and shutting of the doors of these resonators, the undulations of the song are produced.

When the Australian summer is at its hottest, the cicadas mate and lay their eggs high up on the terminal twigs. The female digs with her ovipositor under the bark, and tunnels a cell into which she will lay from six to ten eggs. Then she will pass a little way along the twig and repeat the process. She will lay as many as four hundred eggs—a large family to meet the many risks that must be encountered.

After a few weeks the eggs hatch. The larvae are at first queer fish-shaped creatures, with large eyes, and with their limbs contained in a sheath, which looks like a ventral fin. In this condition they wriggle up out of the cell through the hole left by the ovipositor of their mother. If their limbs were not enclosed in a sheath at this early stage, legs and antennae would become terribly entangled as they each struggle to get through the hole. They would never manage it. As it is, their legs are safe from entanglement and they can wriggle and slide over and amongst one another, and so come to the open, though their hinder ends still remain caught in the hole and so prevent them from falling. The skin which has enfolded the larva during this emergent stage now splits, and the true larva struggles its way out, though it still remains held by its hinder end to the integument. It waits for a while, hardening its tender body in the sunshine; it kicks and tests its strength.

The subsequent larval phase is to be lived under the earth, and there is no future for these tiny, aerial fleas, that are born a hundred feet and more from the ground, unless they jump. Some mysterious impulse, which we call instinct, bids them jump and fling themselves into space. If they were to linger too long on the tree-tops they would wither and die. They must jump to live; and jump they do, and in

their thousands. I have been under eucalyptus trees when these little, flea-like creatures have come showering down. They make a pattering and a rustling on the leaves. A great many must perish at this critical period, for they fall where the wind takes them. Some fall in the water and are drowned. Many are eaten by ants. Some fall on hard rock and wither and die. Those which survive crawl about and do not begin to burrow at once. It appears that there is a certain time ordained for exploration; they crawl at hazard over the earth in the same way that peacock caterpillars will crawl when full-fed before pupating. When they have walked far enough, and the straying instinct is satisfied, they begin to burrow and are soon lost to sight. The next four years are spent underground sucking the juices from roots.

When the full-fed larva emerges from the ground it climbs a suitable support. Here it takes a firm hold and clings until its thorax splits down the middle of the back, and the pale flesh of the emerging insect pushes its way between. The casket which contains the head cracks crosswise, and then, with slow, rhythmical pulsations, the moistly-gleaming insect emerges. When it is free of the old case except for the tip of the abdomen which still remains fixed, the cicada turns over perpendicularly, head downwards, and draws itself out, then pulls itself upright once more, with the fore-legs hooked in the empty skin. The wings are heavy and moist, and the body is still pale in colour. The rhythmical pulsations continue and the wings are gradually expanded to the full size, being pumped full of the green blood, which soon dries and hardens within the veins. Within an hour the colour is darkened to the typical brown, yellow and black, and then at last, after four years in the earth, the cicada is free to enjoy its few weeks of air and sunshine. It spreads its wings in whirring, swift flight towards the tree-tops where hundreds of its kind are sucking the sweet juices and filling the air with their monotonous and all-pervading song.

On low bushes and on the stems of herbs are the empty skins of the larvae which have already experienced transformation. Sometimes as many as a hundred cling to one small bush. The dry, brittle, mud-stained cases still retain their shape though hollow of the insects that once filled them.

STERILITY CORRECTED

When the pollen grains of any flowering plant, either blown by wind or carried by insects, come to rest on the sticky surface of the stigma, they soon begin to send out minute, delicately thrusting tubes, which find their way down the central cavity of the style, and at the base enter the matured ovules. The male generative nuclei pass down these tubes, enter the embryo-sacs and come into close contact with the ova and polar nuclei, thus effecting fertilisation. This is the normal procedure. The elongating pollen tubes do not usually meet with any difficulties in their passage down the style even though the style may be of considerable length.

There are some flowers, however, in which the material of which the stigma is made is of such a texture as not to allow the pollen tubes to penetrate easily into the central cavities and thence to the ovules. In such cases fertilisation by pollination without the aid of some correcting or auxiliary factor is not possible. The yucca, of which several varieties are indigenous to both North and South America, is such a plant, and offers an interesting example of symbiotic relationship between itself and a small moth, by means of which the sterile condition is corrected.

The inflorescence of the yucca is a loosely branching spray of bell-like flowers; they are pale, pearly white, and like the evening prim-

rose open at night for one night only. These flowers are seldom capable of self-fertilisation, for the anthers are considerably shorter than the style, thus not allowing the pollen to approach to the stigma, and even should the pollen fall upon the stigma, fertilisation seldom follows unless the pollen is pressed far down into the central cavity between the three-fold division of the stigma.

Attendant upon these flowers is a small night-flying moth of the genus *Pronuba.* The species of *Pronuba* vary with different species of yucca, but the relation is always similar. *Pronuba* measures barely an inch across the upper wings, which are a shining white; the lower wings are grey. When the insect is in flight, it has a glimmering appearance, similar to that of our English ghost-swifts. It is peculiar in having the first joint of its maxillary palps elongated to an extraordinary extent and curved in a proboscis-like manner into a long tentacle. The inner surface of this is provided with stiff bristles. These tentacles, which can be coiled and uncoiled, are used for collecting pollen from the anthers of the yucca flowers. The pollen is worked into a ball, which is sometimes three times as large as the insect's head, and is carried under the head, and looks like an enormous crop. The female moth alone collects the pollen, and only at such times as she is about to lay her eggs.

As soon as the female moth has collected a sufficiently large ball of pollen, she will select a freshly opened flower, and is careful to avoid flowers which have been open for some hours or have been pierced by other moths. She will then pierce the side of the style (which is the immature fruit) with the horny ovipositor with which she is provided. An egg is laid inside the style at the base of the ovules which there lie in rows side by side. As soon as the moth has laid her egg, she scuttles up to the top of the pistil and begins to stuff pollen from her ball into the cavity between the stigmas. When she has done this to her satisfaction, and she does it with considerable care and precision, she will either run down the style again and deposit another egg, or will fly off to another flower. In every case, as soon as she has laid her egg, she will hurry to the top of the pistil, and cram pollen down into the tube.

The result of this remarkable behaviour is that the pollen tubes can now find their way down to the ovules, and so fertilisation can take place. The ovules, with the exception of those which are placed in the immediate proximity of the eggs, develop into seeds. If those which

are near the eggs were to grow and swell, the eggs would probably be crushed. After an interval of several days larvae emerge, and begin to feed on the growing seeds. They do not eat a great many, never more than a dozen in the course of their development, and since a large number of seeds are produced in each pod, sufficient are left for the autumnal distribution of seeds and reproduction of the plants.

The above are the facts of the strange relationship, which have been most carefully observed and recorded by Professor C. V. Riley and confirmed by Professor William Trelease. If it were not for the strange behaviour of the moth, and the no less strange modifications of its palps, which allow of the collecting of the ball of pollen, it would only be possible in rare and exceptional cases for the yucca plant to set its seed. If it were not for the existence of the yucca plant, the moth *Pronuba* would not be able to live, for it is only on the seeds of the yucca that the young larvae can feed. The two species, plant and moth, are mutually helpful to each other. The moth has developed the obliging habit of collecting pollen and stuffing it down the stigma tube of the yucca flower. The yucca has developed the habit of producing a sufficient number of seeds to satisfy the needs of the moth and leaving enough over for its own purposes. I have used the word *developed*, but is it possible to imagine the external circumstance which would prompt the moth to so strange a method of behaviour, or that would stimulate the development of so peculiar an organ as the tentacle on the maxillary palp? Are we not making a big assumption when we assume that the close-fitting pattern of fate, which is presented by the moth and the plant, is due either to environmental influences or to yet stranger and less accountable fortuitous mutations?

Is it not more honest to admit that our human reason, which is so much in love with a supposed relation between cause and effect, is staggered by the facts of this relationship?

Let us look at further facts which elaborate the surprising pattern. The yucca does not flower every year. Not only do individual plants take periods of rest between their years of inflorescence, but it often happens that all the yucca plants in a locality will flower in certain years, and will miss other years. There are years when no yucca plants are flowering in localities which cover a large area. What happens in those years to the *Pronuba* moths, which on emergence from the pupal state must mate and lay their eggs before they perish? There

are no flowers with ripening ovules. The moths must die before the autumn, and with them not only their generation, but the whole species, since they will leave no descendants. After such a period there will surely be no *Pronuba* moths, and no seed will be set in the yucca flowers which at some later year will blossom.

If the moths emerged from the pupae and found no flowers, no doubt they and their eggs would perish, but on the years when the yuccas withhold their flowers, the *Pronuba* remain dormant in the chrysalis, and wait a time till the yuccas bloom. On the years when the yuccas bloom, the *Pronuba* is there ready to roll her balls of pollen.

That is easy enough to explain you may answer: the same climatic conditions which determine the flowering of the yucca may determine the emergence of the moths. But does that really explain the mystery? Is it not wiser to abandon all theories in the face of such strange facts, and admit only what is obvious, that there is a vital relation between the plant and the moth, whose intricate pattern we can observe, but whose origins still remain lost to us, and scarcely as yet guessed at.

VITAL AFFINITIES

There are hermit-crabs which have mysterious affinities with sea anemones. That the anemone establishes itself on the shell that the crab inhabits by a deliberate act, and not by mere chance, may be demonstrated in the following way. If a hermit-crab is confined in the same aquarium as an anemone which is already attached to a rock, the anemone will, after a short time, abandon its position and, gliding on its basal stalk towards the crab, will fasten itself on the shell. This guileless action makes no disguise of the relationship between these two animals of such different structures, and which appear so far separated in their means of living. The hermit-crab is not merely passive in this association, as may be shown by detaching the anemone from the crab's shell. After an interval of a few seconds, the crab will pick it up in his claws, and pressing it against his shell, hold it there, till such time as the anemone has made itself fast once more.

It would appear from this that both creatures must find some advantage in juxtaposition to each other. How does the crab benefit? Perhaps he is concealed from his enemies by the presence of the polyp, or perhaps the creatures which prey upon him may dislike sea anemones and fear to touch their tentacles, which so often are armed with stinging cells. The anemone may benefit by the fact that the crab

walks about from place to place and so produces a constant change of locality, with an increased chance of procuring food. Or again, when the crab is having a meal, fragments of his food may float up and be seized in the tentacles of the anemone. Such reasoning may appeal to a mind which demands easy explanations, or half-explanations, but when we come to investigate the vital affinities between other diverse pairs of creatures, we will find such ordinary and facile answers far from satisfying.

There are jelly-fish, creatures closely allied to the sea anemone, and also provided with stinging cells, which harbour within their stomachs small fish. These little fishes, much of the size of minnows, though of a more brilliant appearance, seem to have made of the jelly-fish a kind of living, transparent cave, a place of safe retreat, a house to fly to, and take refuge in when threatened by attack—and not only to be inhabited in times of danger, but on other occasions also. Often two or three little fish may be found within the jelly-fish's pouch, when the jelly-fish has been left stranded on the shore between tides. There is enough water in the pouch to keep the fish alive. When the tide returns the jelly-fish again floats, and the little fish emerge into the sea and swim around on their own, until such time as they may again wish to retreat.

There are several mysterious features about this relation. Why are the fish not stung by the nettle-cells of the medusa? How is it they are not digested, as other creatures are, by the juices in the pouch? Do the fishes retreat into the medusa only when threatened by foes who fear to approach within range of the powerful stinging cells which are active against most foreign bodies? Are the stinging cells inactive only against these favoured stomach-dwellers? Or are they active, and are the little fish immune from their poison? There is evidence to suggest that the cells are in some mysterious way made inactive. Another question is: do the jelly-fish derive any advantage from the presence of the fish, or are they merely made use of? These are questions difficult to answer, and our imaginations are left open and wondering at this strange association.

I have myself witnessed another relation of a like nature, which left me at the time only half-credulous of the witness of my eyes, for I did not then know of such strange partnerships. I was on the beach at Hayling Island. One of my children found a jelly-fish on the sand, a creature of about three inches in diameter, and apparently quite dead.

I put it in a bucket of sea water, and we all had a look at it, and were delighted to see that it was alive, and was moving up and down in the bucket with a most graceful, pulsating rhythm. Inside its pouch were two or three little crustaceans of the nature of sand-hoppers. These were moving about inside the stomach, and I assured the children that the jelly-fish had eaten, and was in the process of digesting them. The children kept the jelly-fish to watch and play with it, and after a little came to me with the story that the sand-hoppers had got out of the jelly-fish and were swimming about in the bucket. I did not take much notice of this, and put down the escape of the sand-hoppers to the probably debilitated state of the jelly-fish. Later, when we went to bathe, I took the bucket and emptied it into the sea in shallow water about three feet deep. By this time the sand-hoppers were back again inside the jelly-fish. We all noticed this with great interest. It seemed to me curious that the jelly-fish, in that confined space of the bucket, could have recaptured the sand-hoppers. For the next fifteen minutes, I watched what happened as the jelly-fish swam leisurely and freely about in the shallow water. Some of the sand-hoppers came out and some remained inside. Those that came out swam about in the sea, but did not go into the sand, as I had expected. They returned after a swim of varying distance to the jelly-fish. There was one which went a good forty feet distant, and great was our surprise when it returned and entered the stomach of its all-obliging host, where it remained for a time resting. How could this tiny creature, after having strayed so far in the open sea, find again its own jelly-fish, who in the meanwhile had been drifting freely about? What land-marks or sea-marks could it possibly have? What was the strange affinity which drew it back to its drifting home? Neither my reason nor my imagination could find an answer; and when one comes to question how such a homing-sense could be evolved and maintained by any method of mechanical adaptation to environment, or by the chance mutations of unit-characters, or by chemical reaction, then both imagination and reasoning power are again inadequate in the presence of such facts, which are amply confirmed by other observers.

Another case of affinity is that between the shark and the pilot-fish. A pilot-fish is a small brightly-coloured fish which accompanies the shark and most often precedes him, as though smelling out the way. The shark follows obediently the movements of his little scout. He

never attacks or hurts the pilot-fish, which may at times retreat inside the shark's mouth, and, according to some writers, is even safe to explore as far as his stomach, and return uninjured. So close is this association that the pilot-fish will jump into the air after a captured shark when it is being pulled up out of the sea.

W. H. Hudson in *A Naturalist in La Plata* tells of the affinity that the puma of South America has for man. Although men may hunt the puma and offer it every kind of violence, the puma will never attack men, and will seldom defend itself against attack. It has a quite unaccountable friendliness towards men, and has been known on more than one occasion to stay, all the night through, beside men who have been wounded or incapacitated, and are lying out defenceless on the pampas. The puma, on these occasions, has become a self-appointed guardian, and has fought with and driven off jaguars, who would doubtless, had it not been for the puma's presence, have killed and devoured the wounded men. Such behaviour remains beyond explanation, but it is no less or more wonderful than that of the fish and the medusa or the sand-hoppers and the jelly-fish on Hayling beach.

MORE VITAL AFFINITIES

Among the corals of the Great Barrier Reef there are to be found minute crabs which live in close association with certain species of the more finely branched corals. At an early age the young female crab settles in a position between two branchlets. An irritation is produced by its movements which influences the future growth of the coral, making the branches broaden, and as they grow upwards to unite laterally and to coalesce with each other and so form a spherical cage about the size of a hazel-nut. The narrow crevice into which the crab has worked allows her hardly any movement except in one plane, thus the outward and inward current which the crab produces in the act of respiration has sufficient fixity of direction and continuity to secure a definite result, for this current is probably what determines the growth and shape of the coral chamber. Within this cham-

ber the crab lives safely protected from the shocks and dangers of the external world. A sufficient number of apertures are left to allow for the in-going and out-going currents of water, and in these currents, small particles are borne to and fro, on which the crab can feed.

When the female crab first settles on the branchlet, she is very minute, with a carapace not much more than a millimetre in length. She first lives in a very small chamber formed between the growing branches, but soon this becomes too restricted, and she moves up into the cup which is already being formed by the coral branches themselves. Although the currents of water may have determined the lateral growth of the coral, it still remains unexplained why the branches grow together at the top of the little cage which before long encloses the crab, and in which she is imprisoned for the remainder of her life. Very few specimens of the males of this species of crab have been observed, they are extremely minute and can pass in and out of the small apertures left for the intake of water.

This crab in relation to the coral, whose growth it can control, and which it can persuade to enclose it in a safe refuge, is a creature, which, as we learn of its strange habitat, must evoke both our wonder and speculation. For its own ends it makes a house out of the living substances of other animals; here it lives shut off from the dangers of the outer world. At the price of this safety, it becomes a prisoner, incapable of ever making its escape.

Henrik Steffens, a naturalist-philosopher of the early nineteenth century, made the imaginative observation: 'Animals are fixed ideas incarnate.' The meaning of this statement is not patently obvious, but the contemplation of such life histories as have been described in this and previous chapters should help to reveal its significance.

There is another crab which frequents coral reefs and which has an interesting relation with certain small sea anemones. This crab is provided with claws or chelipeds of very small size, which are of little use for attack or defence. The fingers of these claws are armed with recurved teeth, enabling them to take firm hold on the slippery bodies of small anemones. With their claws, carefully and without injury, the crabs detach the anemones from their hold on the rocks. They then clasp the anemones, one in each claw, and hold them in close proximity to their mouths. The anemones do not appear to suffer from this rough treatment, and continue to spread their tentacles, and to capture any small creatures that are wafted to them in the

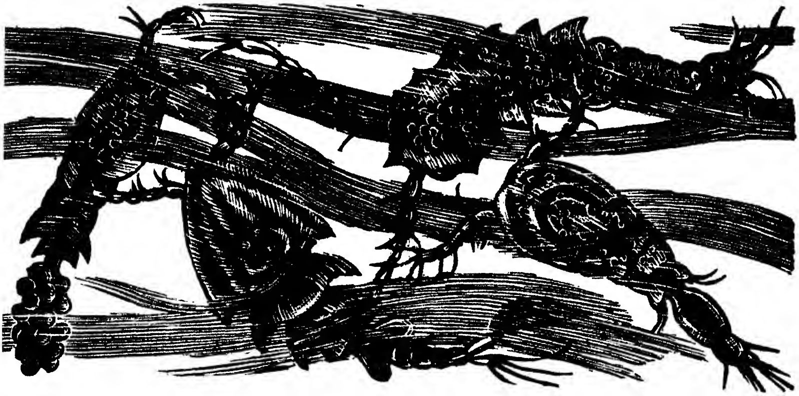
water. The crab, with his first pair of walking legs, removes any titbit that he fancies from the tentacles of the anemone, and eats it himself. In this way his life is made easy for him through the functioning of a completely different species. He is seldom met without one or more anemones in his claws, and this association is developed in the species and not only in individual crabs. Whether the anemones derive any benefit from the partnership is very doubtful.

Another association between vastly different types of living organisms is that between the tree-sloths of South America and certain species of algae. Tree-sloths are mammals characterised by their short faces, rudimentary tails, shaggy coats, and hook-like claws, by which they hang back-downwards from the branches of the trees in tropical forests in which they spend their lives. The most remarkable thing about them is that their hair is green. This green hair is much to their advantage since it makes them very difficult to see amongst the tufts of grey-green lichens among which they live. The hair is long and shaggy and is much coarser than most mammalian hair. If a section be taken of this hair, it is seen to be formed of two parts, an inner central portion and an outer sheath. This outer sheath is divided by a number of transverse cracks, and in these cracks there lives and flourishes a primitive plant, a one-celled alga.

In the damp, tropical forests, the algae in the cracks of the hairs find sufficient moisture, and by means of their green chloroplasts extract carbon dioxide from the air, and so increase and multiply. Their lives are by no means parasitic on the sloth, yet they find a safe harbourage in his long, coarse hairs, and by the green of their chloroplasts they bestow on him the true colour of vegetation. In this association, both species benefit, yet neither can be even remotely aware of the other.

The above description is of the three-toed sloth or aï. The two-toed sloth also inhabits the same tropical forests, and it is a remarkable fact that the hairs of this creature are of a different structure from that of the three-toed. The hairs in this case have no outer cortex, but are furrowed with longitudinal grooves. In these grooves live the cells of a different and distinct species of alga. The effect in both cases is the same, but the mechanism is different. The hairs in both species of sloth are long and shaggy and would seem to imitate tufts of lichen, so that the body of the sloth, as it hangs upside-down in the tree, would appear like a lichen-clad knot of wood. But only if these hairs are

green is the protective device effective. Now it is assumed by evolutionists that the tree-sloths have been developed from some ancestral ground-living species. The question presents itself: was the power of natural selection adequate to produce the shaggy, lichen-like hair in the arboreal sloths, and *at the same time* to produce the particular structures in the hairs themselves that allow of the association of the algae? Unless these characters occurred simultaneously they would each lose the greater part of their usefulness.



FOR MERE LIFE'S SAKE

When the larva of the common rock barnacle emerges from the egg, it is a tiny, free-swimming creature. It spends the first portion of its existence floating and swimming on the surface of the ocean together with millions of other small transparent larvae of akin species, amidst the vast host of all those other floating, transparent animals which live on or near the sea's surface. It grows and, as it grows, changes its form with each skin-change, until the time comes for it to take on a quite different habit of life. Then suddenly and at a single moult, it passes into a condition in which the body and limbs are enclosed in a bi-valve shell. At this stage the first pair of its antennules project between the valves of the shell. On each of these antennules there is a sucker, by means of which the larva, after swimming about for a time, attaches itself to a stone or other object where it remains fixed for the rest of its life. A cementing substance is produced by a gland at the base of the antennules, which attaches the front part of the head firmly to the support. After a short time the first larval shell is cast off and replaced by the valves of the adult shell, in which the barnacle lives enclosed.

The barnacle and its allied genera are so unlike the normal types of crustaceans that for a long while they were classified as molluscs;

only when the larval stages were studied, which are typically crustacean, were these sessile creatures recognised as being allied to jointed-legged, free-moving animals such as crabs, lobsters, wood-lice, etc. The barnacle is, as I have described, anchored by the head, and when we regard it as a specially modified crustacean, we see it as lying on its back, and kicking the food, which comes to it in the water, into its mouth by means of its long, oar-like legs. It may well be assumed that this creature has been produced by a process of development from the more normal type. It has become specialised to a sedentary life, and in the process has lost the normal characteristics, and has produced other peculiar structures which mask and disguise its origin.

There are other allied species which have gone further than the rock barnacle along this road of devolution. There are barnacles which are found only on the shells of turtles, and others which live attached to the bodies of whales. These latter are specially adapted to cling close to the moving surface of the skin; they suck folds of the whale's blubber into special cavities of their shells and so hold the tighter. There are other allied species which attach themselves to the bodies of sharks and dog-fish. In these a root-like process is developed from the head which not only serves as a means of attachment, but draws nourishment from the body of the host. And there are yet other species in which this process of devolution has gone further, to the most extreme lengths, where the parasite has lost all resemblance to type, and has become devoid of almost every characteristic which we associate with the life of animals. Such a creature is *Sacculina.*

The larva of *Sacculina*, which is a typical crustacean larva, swims freely in the sea till it attaches itself to some exposed portion of a crab, often one of the legs. Here, for a time, it clings on to a hair by means of its antennules. Its subsequent behaviour is most extraordinary. The larva bores through the cuticle at the base of the hair, and then the contents of its body passes into the interior of the crab as a formless mass of cells. The shell of the larva is left clinging to the crab's leg, and soon falls off. The mass of cells, which may now be regarded as the embryo of the parasite, is carried about in the blood-stream of the crab until it comes in contact with the underside of the intestine. Here it becomes attached. It grows, absorbing the juices of the crab, and it sends out root-like structures into the crab's tissue. In time it travels backwards along the intestine till it reaches the underside of

the abdomen. Here it remains inside the crab until such time as the crab undergoes its next moult. After the moult a portion of the parasite protrudes externally in the form of a fleshy, sac-like mass on the underside of the abdomen. This fleshy mass is far removed both in appearance and structure, from the typical free-moving crustacean, and had it not been for the larva, no one would ever have suspected any relationship.

The *Sacculina* now lives by means of the root-like branches which surround the intestine of the host, and which take nourishment therefrom. How this extraordinary capacity to pass into the crab's body in a formless mass of cells has been achieved by the *Sacculina* remains a mystery, which can only be compared with that strange breaking up of tissues which takes place during the metamorphosis of such large classes of insects as the *Lepidoptera*. The question presents itself: what is the governing life principle which guides this formless mass of cells to its appointed end? And can the whole mysterious relationship be explained by mechanistic theories of chemical and physical reactions?

Another case of extreme modification is offered by an allied genus called *Thompsonia*. *Thompsonia* is found living parasitically on certain prawns and shrimps. Externally the parasite consists of a number of small, protruding sacs, sometimes as many as two hundred to a single host. When *Thompsonia* first came under observation, it was assumed that each of these sacs was a separate parasite, but Mr. F. A. Potts has now demonstrated that these sacs are all processes from a central root-system within the host. This root-system can be compared to the mycelium of a fungus, and in fact it might well be described as a mycelium, a thin thread, which winds most thickly around the dorsal nerve cords of the host, and which sends branching threads down into the muscles. Lateral roots pass out into the limbs and swimmerets, and it is on the ends of these that the external sacs are budded out. Within the sacs, the ova grow, mature and undergo their whole development. The eggs develop into larvae while still within the membrane of the sac. When they are ready for a free existence, the sacs burst, and the larvae, which are typically crustacean, escape into the sea.

This creature has almost forfeited its right to be called an animal. It is a mere thread, a mycelium, nourishing and producing a number of egg-bearing sacs. It has no senses, no organs save reproductive,

and its affinities in the world of living things are only recognised through its larvae. It exists for mere life's sake, without hearing, sight, sense of smell or touch, and probably without even sensibility to pain. Degeneration could hardly go further, and yet this creature follows always the same general manner of weaving its mycelium about the dorsal nervous system of its host. There is an order and correspondence which does not vary beyond definitely set limits; the reproductive sacs are budded from the ends of the mycelium in crops, all appearing and ripening at the same time, and Mr. Potts suggests that this ripening of the sacs synchronises with those times that the host casts his skin. When the host casts his skin the sacs of *Thompsonia* are cast off with it. If the larvae were not ready for the free-swimming stage they would perish. In this fact there is an intimation that the life rhythms of the host and the parasite are in some unexplained way closely associated.

TRANSFORMATIONS

The metamorphosis which takes place in the life cycle of insects, and especially that complete series of transformations within the life history of butterflies and moths, has been taken as a significant expression of the transformative processes of life. The essential differences in form, size and habit which separate the early phases of the larva from the perfect insect cannot fail to capture the attention of any observer, and to evoke the question: How can the transformations from larva to pupa, to imago, be reconciled with the concept of continuous transformations by innumerable, slow variations or with the concept of uninterrupted evolution by gradual functional changes; and further, how can the phenomenon of histolysis (the solution of the tissues) in the chrysalis, by which most of the organs are reduced to an amorphous emulsion, preparatory to the coming metamorphosis, be brought about by purely mechanistic, physico-chemical reactions? Is there not here revealed a testimony which declares that neither the changes in the larva nor the mysterious solution of the tissues in the chrysalis lead up to, or in any obvious way anticipate, the future morphology of the perfect insect; and, is not the conclusion unavoidable that this testimony reveals the existence of an ideal, proper to and working within the organisms in question? This

ideal or 'final cause' being the determining factor which governs the transformations.

The process of such transformations can be observed in the life history of any butterfly or moth. In the following account, I have selected that of the swallow-tail butterfly, as one with which I have had opportunity of making myself familiar.

In June, or at the earliest the end of May, the first flight of the perfect insects takes place. In Wicken Fen in Cambridgeshire, and in various places in Norfolk, these butterflies are fairly common. They are very sensitive to weather conditions, and only fly on days when sun, wind and moisture are to their liking. By the end of June, the females are laying their eggs on the young leaves of the wild carrot, which grows most freely in the places where the sedge has been recently cut. These eggs are bright yellow and easy to see. Very soon, usually in about a week's time, the young caterpillars emerge. They are black with a tiny white band, and they sit on the ends of the leaf-fronds, making no attempt to conceal themselves. In a few days, they change their skins, or rather burst their way out of the skins with which they were first provided, and which are now too small for them. The new skin, which has been formed beneath the old one, looks on first emergence too large for the contained caterpillar, and so it is, for it is large enough to allow room for growth; and when the caterpillar has grown so that this skin in turn is stretched to full capacity, it splits, and the larva emerges with yet another new skin, which has grown beneath the old one. At these skin changes, the head, or rather the chitinous head-covering, is also shed, and if the larva is observed just before the change, the old head can be seen, sitting like a small hat upon the new, larger head which is beneath.

At the time of the change, the caterpillar will spin a small silk mat on which to fasten its claspers. Only when the claspers are firmly secured, is the caterpillar able to walk out of the old skin, and leave it fastened to the mat. It is usually fatal to the larva to move it from its mat at the time of skin changing, for if the hold is broken, and the caterpillar has entered into the quiescent stage which precedes the change, it is unable to make a new hold, and so unable to walk clear of the old covering, which remains tightly about it, and it dies. For this reason, it is a good plan, when collecting caterpillars, never to move them from their food-plant, but to pick the spray on which they are feeding.

At each skin change the young swallow-tail becomes more brightly marked. At the second change the white band is broader and has markings of orange and red. The full-fed larva is very conspicuous in stripes of yellowy-green and black with red tubercles on the black bands. If it is alarmed, it will bend its first few segments into an arch, and from between the second and third segments will produce pale, orange emergences, which look like tentacles, and at the same time a drop of pungent liquid will be extruded. This probably serves to warn any ill-advised bird that this creature, with its brilliant colours, will afford an unpleasant-tasting mouthful.

After thirty days from the emergence from the egg, the caterpillar is fully fed, and is ready for the change into the pupa stage. This readiness for change is announced by a restlessness and a desire to walk. When kept in captivity, there is no need for a hutch in which to confine these larvae; they will sit during the period of their growth peacefully on their food-plant; but at this later stage, they will leave the food-plant, and, if not shut up, will be found going at a full gallop all over the room. This activity is not produced by want of food, nor is it primarily a search for a good place to pupate. It is engendered by an inner restlessness, and seems to be undertaken for the sake of mere walking. In some species it is more marked than in the swallow-tail. The larvae of the peacock butterfly will walk a great distance at this time, and many caterpillars show signs of being ill at ease, and have a definitely sickly appearance, indicating that the changes of their coming metamorphosis are already at work within them. Their colour changes, and a marked shrinkage of size is noticeable. This walking-sickness, as it may well be called, fulfils the purpose of distributing the individual larvae over wide areas, and in natural conditions they are scattered far from the place where the parent insect deposited the eggs, and in gregarious caterpillars, such as those of the peacock and small tortoise-shell, this must be a definite help. In the breeding cage or in a room, the caterpillars will walk the destined number of yards, round and round and up and down, and will then begin the important business of preparing for the change.

In the case of the swallow-tail, the insects are now definitely smaller than when, full-fed, they began to walk, and of a yellower colour. The first act is to spin a firm, thick mat on which to fix the hind claspers. This is usually made on the dry stalk of a reed or blade of sedge. In an upright position, with the hind claspers fixed to the

mat, the larva spins the band which is to hold the pupa in position. This difficult task involves much neck-bending. From side to side the head goes, while the fore-feet guide and fasten the thread as far down the reed-stem as they can reach. This work is done slowly and with numerous rests. When it is completed, the caterpillar is circled round the back by a strong silk cord. It now rests facing the reed-stem and with the legs drawn close up under the head. During this period of rest the body shrinks and becomes noticeably smaller, and towards the later part of the time, all the claspers but the last pair release their hold on the reed, and the creature leans on its band of silk in a shape which is already suggestive of the pupa which is to be.

At the appointed time, usually after about fifty hours of quiescence, definite and rhythmical movements can be observed. These swell from the posterior to the anterior end and announce the immediate change from larva to pupa. These swellings and contractings become more marked until they become sufficiently violent to break the thin larval skin, which splits down the back, and a green, tender body seems definitely to push itself through the widening gap, and at the same time, the skin, as though pulled back by some invisible instruments, slips further and further towards the posterior end. It passes, in a way which appears quite miraculous, the silk cord, which one would expect to entangle it, and by what can only be described as the most extraordinary dexterity of wriggling, the now naked pupa works the skin down to the region of the hind claspers. As a penultimate act, it releases its hold on the silk mat, draws up the tail (it is now supported only by the silk cord, which looks perilously like slipping), lifts clear of the skin, pushes the skin aside, and finally fastens again on the mat, giving as a seal of its accomplishment a few quick turns to make secure its hold.

The empty skin falls, and the pupa now occupies the place of the larva, but it has not yet assumed the final pupal form. The posterior end is much rounder than it will soon become, and the part where the eyes and the head are to be is still snub and soft. This condition changes within twenty minutes, the chrysalis takes its final shape, and the outer integument hardens.

The shape and position of the organs of the butterfly which is to be are already stamped on the pupa. It should be particularly noticed that these marks are on the *outside* and that there is nothing yet formed inside to correspond with them. This is a significant fact, and

one which, when its significance is grasped, will modify the accepted idea that development takes place always and only from a centre outwards. The governing ideal has at this stage at last declared itself, and although there is, within the creature, at this stage, nothing but a green watery pulp, all the places in its organism which are later to be occupied by legs, wings, antennae, etc., are now definitely marked. They are waiting to be filled by the organs, not yet made, but already determined.

The changes which go on within are no less and perhaps even more wonderful than those which have been visible from the outside. A breaking-down of the tissues is taking place, and has been taking place for some time. Cells which are comparable to white blood-corpuscles are generated in large numbers at this time, and these devour most of the organs which have functioned in the caterpillar, reducing them to a kind of soup. These changes within the chrysalis are not altogether known, and even in their physical aspect remain very much of a mystery, but it is maintained that the tissues which are reduced by the phagocytes comprise the hypodermic cells of the first four segments, the breathing tubes, the muscles, the fatty-bodies and the peripheral nerves, and of these there remain no cellular elements. They are reduced to a non-cellular mush. At the same time as this change is taking place, the cells of the middle intestine assemble into a central mass. Later a new generation of tissue is formed, partly from this central intestinal magma, and partly from the proliferation of special corpuscles called image-bearing disks. Thus it is that the newly-formed portions seem to have no direct filiation with the destroyed parts of the larval organism. The creature has in fact died, in so far as it has lost its form, its organs and its habits, and now, in a manner which cannot be described as anything but mysterious, is experiencing a new orientation towards a quite different form, which is to find its expression in a quite different mode of life.

In this process of metamorphosis, it may be maintained that we appear to be in the presence of the working of a concrete idea upon a plastic material. The idea of what the future insect is to be impresses itself on a substance which has become non-structural and amorphous. If this statement is questioned, the questioner has but to look at the form impressed on the outer integument of the chrysalis, when as yet no organs are formed within it. What we have witnessed is the working of a centralising and directive force, which de-

termines the chemical and physical reactions of the organic medium.

Although the changes which take place within the pupal case remain to a large extent obscure, the emergence of the butterfly can easily be observed, and is in itself a thing which will fill any observer with wonder. Caterpillars which have been brought up in captivity can be induced to pupate on convenient reed-stems, and these if kept out of the sun usually produce butterflies the following June. Unfortunately, I have never been able to observe the pupae in their native habitat, for although the larvae and ova are easy to find, the pupae are very difficult to see, as their colour, which is green or grey-black, blends perfectly with their surroundings. It would be interesting to know whether the pupa at any stage in its metamorphosis is acceptable to the palate of birds, and whether it is for this reason that it is protectively coloured.

The emergence of the butterfly usually takes place between seven and eight in the morning. For some days previously the markings of the butterfly have been visible through the thin transparent shuck of the pupa. These markings, which on their first appearance are but faint, become darker daily, until on the last day the tone is mottled black, and yellow, these being the predominant colourings of the emerged insect.

The first sign that a change is about to take place is an expanding of the thoracic region. This is at first rhythmical and barely to be marked, but it soon becomes more violent and spasmodic, and before long the pupa-shuck splits down the back and across the shoulders. The internal swellings and contractings become still more marked, though often relieved with intervals of rest, and soon the broad, black back of the butterfly begins to push itself out and up; at the same time that this happens, the front of the pupa-case cracks in several places in the region of the legs and antennae. Soon the legs are thrust forth, the antennae are released and the trunk withdrawn from its sheath where it has lain. With an effort which now reaches its climax, the butterfly lifts itself on its newly-freed legs up on to the reed and draws the abdomen free of the case. Sometimes it will rest on the case itself, but more frequently on the reed. On its back are crumpled and misshapen masses, which are the wings; these are small, fleshy and thick, and give the creature, at this stage, a crippled appearance.

As soon as the insect has found a firm standing-ground, at the correct angle so that the wings can hang down over the back, it remains

quite still except for the regular pumping movement, which is effected by a swelling and contracting of the thorax. By this movement the green, sap-like blood is pumped into the nervures of the wings, and thus gradually expands them. As the wings grow larger they fall back limply over the back, and, should they now by any mischance become injured, the blood will well out of the wound, and the wing fail to develop properly. If no such accident occurs, the pumping movement will continue until the wings are fully expanded, then it will cease, and the insect, now perfect, will remain quiescent while the blood within the nervures hardens and dries and becomes the stiff, resilient substance which is destined to take the weight of the creature when in flight. After about three-quarters of an hour's pause, the butterfly is ready to take the air, but usually it remains resting for a considerably longer time.

From the eggs which were laid in June a certain number of perfect insects emerge in August or September, but the larger number remain in the pupa during the winter and do not emerge till the following June. These specimens which emerge in August lay eggs and produce another brood of caterpillars. These pupate in September, and also pass the winter in the pupal state, to emerge in company with those which pupated earlier; consequently the June flight of butterflies is always the most numerous.

In this way the various metamorphoses of the life history are completed, and the 'final cause' of all that obscure yet definitely directed striving is completed.

FARMER'S FRIENDS AND FOES

Every gardener knows what a nuisance field-mice can be when the time comes for the spring planting of peas. If once the mice find the row, they are likely to clear it, and even though the seeds are soaked in paraffin and rolled in lead oxide, the mice will have them, and leave the red, poisoned shucks on the surface for the gardener to mourn over. Mice do a great deal of harm, and not only by the eating of seeds and grain in the springtime, but by the raiding of humble-bees' nests in the summer.

Humble-bees, and how they live and rear their young, have been described in an earlier chapter. They are insects which are very definitely useful to the farmer, for they help to fertilise the clover, and there are some kinds of clover, namely the Dutch Clover (*Trifolium repens*) and the Red Clover (*Trifolium pratense*), which are almost entirely fertilised by humble-bees. Experiments have been done to show that twenty heads of Dutch clover yielded 2,290 seeds and twenty other heads that were protected from bees produced not one. The humble-bee then should be counted as one of the often unrecognised and humble friends of the farmer. For this reason the intelligent

farmer will try to look after the welfare of his friends. He can best do this by bringing down the number of mice.

Now it has been calculated that field-mice destroy more than two-thirds of the humble-bees in England every year, and it has also been found that there are more humble-bees' nests near villages than in the open country, and this for the simple reason that there are cats in villages, and that cats eat mice. And so cats ought to be counted as friends of the farmer, and even the old spinster ladies who keep the cats ought not to be left out.

There are districts in Germany where a great deal of seed clover is grown, and here some of the farmers, the more intelligent of them, put up T-shaped perches about eight feet high and three feet wide along the sides of their fields. A stranger coming to the neighbourhood for the first time might well wonder what they are for. They are for the owls and the hawks to perch on. Owls and hawks eat an enormous number of mice, and the owl or the hawk can see the mice better if he has a perch about eight or ten feet off the ground. That is why the German farmers find it worth their while to put up the perches. And of course they would never be so foolish as to shoot an owl or a hawk, knowing as they do that the owls and hawks are among their best friends.

Some of my readers may think that the perch would not make so much difference, but a perch or vantage-point is used by any hunter, and one only has to keep one's eyes open to notice this. There is a table that stands out in my orchard at which we have meals in fine weather. This table is very much used by two cats who are great mouse hunters. I have again and again seen them spring down on to the mice and they never fail to make a catch. In the same way the perches are of use to the hawks and the owls.

While I am talking about owls, I cannot resist a protest against the way in which gamekeepers so often shoot these beautiful and useful birds. Owls, with the possible exception of the little owl, do far more good than harm. And particularly useful is the barn or white owl. This noble bird was far commoner in my youth than it is today, and the reason of its decline is that too few people know how very useful this bird is. The barn owl lives almost entirely on rats, mice, shrews, insects and sparrows. Often one can see them hunting the ricks in winter for roosting sparrows, or swooping on their silent wings close to ivy or evergreen bushes hunting the same prey. More than once

I have seen a barn owl swallow a young rat whole; on each occasion the tail was left hanging from the mouth. For some time it remained there while the portion that was further down was being digested.

Another bird which should be numbered amongst the farmer's friends is the plover or pee-wit. These birds eat an enormous number of wireworms and there is no evidence that they ever attack crops. Every countryman knows that there are far more lapwings or green plovers in our fields in winter than in summer. They are great wanderers and come south from northern countries to these shores. A good deal of work has been done by naturalists to find out where these birds come from and where they go to. Birds have been caught and rings put on their legs with descriptive labels attached. Many birds ringed abroad are found here in winter, these are chiefly from Scandinavia and Germany. Young birds marked in England and Scotland are sometimes found close to their breeding ground; a large number remain at home, but others wander, and have been found in Ireland, France and Spain, and even as far as Africa. Very few of the English birds wander north.

When they are migrating they travel at great heights, often so high up that they are invisible from the ground. Airmen have observed flocks as high as six thousand five hundred feet. In the early spring and late autumn when the flocks are at their largest, the plovers will indulge in marvellous aerial manoeuvres, often mixing with gulls, jackdaws and rooks to make what is indeed a lovely sight against a background of high clouds. The plovers are always distinguishable by their quick turns and the swaying, changing flight. There are times when they rush earthward through the flocks of the other birds, and seem intent on dashing themselves against the ground. Only at the last moment do they swerve aside, and with their characteristic cry of pee-wit, begin to climb the air once more.

We all know their green mottled eggs, laid four in a clutch on the bare ground. These are protected by law, a law not so rigidly enforced as it should be, as a considerable traffic is still done in the eggs. These are birds that do only good to the farmer and have no bad habits.

Having mentioned some of the creatures which are friends to the farmer, I should not forget his foes. One of the most destructive of British birds is the magpie. He is intelligent and beautiful, but terribly bad for young ducks and young chickens, but especially does he love to eat up young ducklings and leave nothing to tell the tale of his early

morning breakfast but their yellow feet. When the ducklings are small, he will polish off a whole brood at a time, and when they are older, even if they are too old to be killed and eaten, he will so peck at their necks that they will die soon after. The only way to protect the young birds is to have them under wire or to shut them in safely every night and not let them out till the farm hands are about. Otherwise the magpies come in the early dawn, and the young ducklings are no more. Magpies are also great egg eaters and all through the spring months they devour the eggs and young of other birds. All game-keepers know how destructive jays and magpies are to pheasants' eggs.

Though magpies are very clever at avoiding the man with the gun, once they are caught, they are very easy to tame, and they make very attractive pets indeed. In the winter they gather together into quite large flocks, and in the spring these flocks become even larger; they form in fact what have been called marriage parties. They meet together for the purpose of choosing their mates. Sometimes as many as two hundred may be seen disputing and showing off, the males opening and closing their tails and raising and depressing their crests, and making themselves attractive to the female eye. They make short, buoyant flights and are indeed a beautiful sight to watch during these marriage meetings.

In northern countries where the winters are hard, magpies have been known, when pressed by hunger, to attack larger animals, and even men and women. Large flocks of them work together, and if there is a sore place on donkey or pony, they will attack it with their sharp beaks, and in a little while penetrate, as do the New Zealand sheep-killing parrots, to vital organs.

Among the smaller birds, the bullfinch is perhaps the most persistent enemy of man. This most beautiful and attractive bird is a real plague to fruit farmers and all gardeners. He has a springtime passion for salads, and as the only young green things then available are buds, buds he eats. There are some people who try to apologise for the bullfinch and say that he only eats worm-infected buds and that it isn't the bud he eats, but the worm. This is quite untrue. His attacks are deliberate, and he knows what he is about. He will perch on the stem, and will pick off one fruit bud after another, just tasting them and letting them drop. He prefers plum buds to pear buds, but when he has eaten all the plum buds he will show no hesitation about attack-

ing the pears. And when he has eaten all the pear buds, he will turn his attention to the apples. It is rather difficult to understand why the bullfinch should be numbered amongst the wild birds that are protected by law when he is so exceptionally destructive, and when one bird can work in such a short time a devastation that brings to naught all the care of the fruit-farmer.

THE OWL AND THE BEETLE

The Little Owl is not a truly British species, but was introduced by Lord Milford some years ago from Holland. The first birds that were brought over were let loose on Wicken Fen in Cambridgeshire, and have since spread widely over England, and are now fairly common in most districts. It is not popular with gamekeepers or chicken-farmers, who accuse it of killing and eating young pheasants and chickens. Naturalists and bird-lovers have tried to make excuses for it, and tried to whitewash its character by pointing out that its diet is almost entirely composed of beetles and other insects. This argument in its favour the owl does its best to support, for it has a habit, in common with other species of its kind, of bringing up a cast or pellet of the indigestible portion of its food. These pellets when they are collected and examined are found to be almost entirely made up of the broken wing-cases of beetles. There are no bones or feathers and often not much fur. 'And so,' say the naturalists and the bird-lovers to the gamekeepers and the chicken-farmers, 'you are mistaken, these birds are innocent, they only eat insects.' 'But,' say the keepers, 'we know the little owl takes the young pheasants, because we've seen him do it, not once but often, and we have shot him too, with the young birds in his claws.' 'Yes, and the same is true of young

chickens,' say the farmers. 'The owl's a nuisance, and it was a fool who ever brought it to England to be a plague to us.'

The bird-specialists answer: 'But he doesn't eat the birds, or he'd be bound to bring up the bones and the feathers in his casts.'

A close observation of the habits of the little owl has proved that both are right in their contentions. He does kill the young pheasants and chicks, but he doesn't eat them.

It was found by analysing the contents of the casts that these were made up, during the earlier part of the year, in April and May, of the remains of the harder parts of the burying beetle and of those beetles whose habit it is to live upon the dead bodies of animals. This gave the observers a clue, and they found that the little owl would search for the dead bodies of small animals, and seek under them, turning them over with its beak and claws, for the beetles which it finds so appetising. And not only that; it will regularly and systematically kill young birds and small animals such as mice and rats, and will carry the bodies to certain selected places, and will there leave them to become of the right sweetness of decomposition to attract the beetles.

After a day or two, this sagacious bird will return to his private collection, and will find his traps well stocked. All he has to do is to turn over the small corpses and find the beetles underneath.

These burying beetles are also interesting creatures, and can be best observed in April and May, when engaged in the task of burying the dead bodies in which their grubs are to find both habitation and food. The true burying beetle does not eat much of the corpse he is burying; he prepares it as a fit feeding ground for his young.He will bury it by working the ground away from underneath the corpse, and so letting the body fall into the space that he hollows out. The process is amazingly quick, provided the soil is suitably soft, and the little owls, if they are going to catch the beetles before they are too deeply buried, have to make frequent visits to their hunting-grounds.

The question arises: is this action of the little owl due to intelligence and reasoned deduction from facts, or is it the working of a complicated instinct whose origin remains obscure? It is worth while analysing what the process of reasoning would have to be, and examining the simple judgments which we will have to presuppose on the part of the owl. To begin with we may make the assumption that the owl likes the beetles. It finds the beetles that it likes best in the close proximity to the bodies of dead animals. So often does this experi-

ence occur that the association between dead bodies and beetles becomes established in its mind. Therefore when it wants to find the beetles that it most likes, it searches for the dead bodies of animals, and in this search for dead bodies it finds that they are not so frequent as it would wish.

So far, these associations of thought are fairly simple, but now comes a slightly more difficult one. It recognised the existence of live animals similar to those which it has found dead, and is able to make a definite and correct judgment as to the similarity. It then discovers, or it may be taught by the example of older birds, that it has the power of making a live animal into a dead one. But this newly-made dead animal has no beetles about it. The next step in the owl's reasoning is more difficult. It must recognise that a time interval is necessary, and must in some way or another come to the following conclusion: 'This dead body which I hold in my claws has no beetles in it now, but if I leave it in a suitable place which I can remember, and return to, it will in the course of time become rich in the beetles which I most like.' Such a reasoning must postulate on the part of the owl a sense of duration, also foresight and memory. This shows in fact a fairly high degree of intelligence as judged from a human standard. It is quite possible that the owl has such a standard of intelligence, and does go through steps of reasoning similar to those which have been indicated, but it is also possible that the determinants of its action are quite different from human determinants, and that it may be governed by an autonomous complex similar to those which are revealed in wholly instinctive creatures such as insects, of which examples have already been described.

OF SWALLOWS AND STARLINGS

Strange as it may seem, a large number of people do not distinguish between swallows, martins and swifts. These birds, although possessing considerable resemblances in their structure and flight, are quite easily distinguished. The swifts are completely black, are the largest of these species, and in flight the curve of their wings forms the arc of a circle. The swallow has a blue back, and chestnut and blue breast bands, and long tail-streamers. The house-martin has a white rump and underparts, and a short tail. The sand-martin is a smaller bird than the house-martin and is brown above and white below. All these birds are often loosely grouped together as swallows, but with very little discrimination they can easily be told apart.

In the spring we all look eagerly for the coming of the first 'swallow', which is usually a house-martin, but, I think the late summer is the most interesting time to observe these birds. When the young house-martins have first learned to fly, the parent birds are divided in their activities by two conflicting instincts: one which prompts them to feed the young, which seem quite capable to feed themselves, but are too lazy, and the instinct to start new nests and produce late, second broods.

Since both these instincts are very strong in them they are kept terribly busy. They swoop to and fro, collecting mouthfuls of flies,

which they disgorge into the hungry beaks of their clamouring brood, and then rush back to the banks of pond or stream to gather mud to start new nests, then back to feed the young ones, and so it goes on all day. The new nests grow so slowly that often nothing comes of them, and it may be that this late-nesting instinct merely serves to prevent the parent birds from being over-solicitous for their full-grown children. These young birds are very reluctant to leave the nest, and when once they have left it, find it very difficult to get back again. Although the young martin can fly as soon as he takes the first desperate plunge, it is some time before he can use his legs and claws to any effect. He finds it very difficult to balance, and it is no small feat to fly gracefully up to a small aperture and cling to the lip of the nest as the parent-birds do. I have seen the young birds come up ten, twenty or thirty times, flutter near by, and yet not have the courage to make a plunge into the hole. When at last they do so, they often make a mis-shot, or else fall clumsily into the nest on their heads. Perhaps if the parent-birds were not diverted by their late nest-building, the young would be so well supplied with food, they would not venture out of the nest that they find so difficult to regain. And it is worth mentioning, that a large number of birds of various other species, once they have left the nest, never return to it.

The swifts or 'screechers', as they are usually called by country people, are one of the most interesting of English birds. They are so wonderfully modified for flight that they live almost entirely in the air, and their short legs are only adapted for clinging. Should a swift be mistaken enough to settle on the ground, it cannot rise again; it has to be able to let itself fall from a height to get sufficient play for its long, thin wings to feel the air. But once they have found it, how marvellously do they then fly! They do, indeed, scorn the earth or any traffic with it. At nesting time the females, like those of other birds, sit on their eggs, but it would appear that they are reluctant to perform this maternal duty. The males can often be seen and heard pursuing their wives with loud screechings, and driving them on to their nests.

After the hen birds are at last settled on the nests, the husbands consider themselves at liberty to disport themselves after their own fashion. They swoop and circle in the evening air, ever rising higher and higher, until at last they are lost to view, and only their cries sound faintly from the zenith. All night they fly to and fro, in wide-

swooping curves, up there in the darkness. Perhaps they sleep on the wing, or perhaps merely drowse in a kind of airy stupor; whatever they do, they are following the instinct which drives them from the earth. There is evidence that they go very high indeed. I have never been fortunate enough to see them on their morning return to the earth, but W. H. Hudson gives an account of how at early dawn he saw a shepherd boy on the downs peering searchingly into the sky. He asked the lad what he was looking at, and the boy said he was watching to see the 'screechers' come down after their night's rest. This was the place they came down, he said, and he had often seen them come hurtling and screeching from the heights where they had spent the hours of darkness. Is it surprising that the human mind should have conceived of the martlet, the mythical bird that has no legs, that lives always in the air?

In the autumn, many of the young and the old birds which stay in England form into large flocks. Amongst the most noticeable of these are the starlings. Thousands of them are to be seen every evening gathering in reed-beds or copses, and these flocks get increasingly larger as more of the late-hatched families come to join them. The gatherings of the starlings at sunset are among the most wonderful sights that the English countryside has to offer. The birds come in groups and parties from all quarters to join the main flock. Sometimes thirty or forty in a group, sometimes several hundreds. They come whizzing through the air at a tremendous pace, and when they have found the main population, they execute evolutions of wheelings and swoopings, in the larger, merged flock, and bend and turn their flight over the reed-beds, while still later comers join them. Sometimes they are like a vast, black ribbon drawn across the sky, then suddenly they will rush together to a centre, to re-form, in outward moving patterns, the figure of some vast animal, then, like a wing of a bird, they spread out, and are lifted, till again at a sudden unseen signal, they are poured out like numberless black drops of water, and spread in a low-sweeping veil over the earth, to rise again and re-form, and again joined by others, continue their marvellous twilight dance, which expresses in so memorable and significant fashion the soul and essence of the flock.

I have stood watching, at one time and another, close under the rush of their wings for many hours, and while they have gathered for their night-roosting, I have both seen and felt the power of their

collective being. They do not on these occasions appear as separate individuals, but all are swayed by the intuitive will of the species; every wing turns at the determined moment, yet they turn, not in precisely the same way, but with that slight difference, which makes for and creates these marvellous, ever-changing and re-forming patterns, which result in such a surprising miracle of beauty.

At last they go down into the sedge, and the reeds bend and sway under their weight. There is a tremendous noise of chattering and scolding, which can be heard from a far distance, and often before they are settled, they will rise again, and circle and rush wildly to greet some late-comers, then again, like black drops pour themselves out on to the reeds, which are almost flattened by their weight. At last, a full hour later than their first gathering, they begin to settle down for the night. The chattering becomes less, the twilight darkens, and the last few birds drop down to roost. Slowly they become quieter and quieter.

SMALL BIRDS IN WINTER

When the winds of early December have stripped the trees of their leaves, the small birds, which escape notice in summer, can then be more easily seen. Along the hedge-rows and in the copses there are large flocks of titmice; all the young birds of the summer's hatching are here with their parents, no longer in families, but forming the larger community of the flock, great-tits, cole-tits, blue-tits and marsh-tits, and sometimes, but not always, long-tailed-tits, or bottle-tits as they are sometimes called, are amongst them. These latter are one of the most beautiful of English birds, and well worth a close inspection. They have curious high-domed foreheads, flat faces with a Chinese expression about them, tiny, beady-black eyes, red eyelids and extravagantly long tails. Their body-colouring is of mauve, grey, white, pink and black, all blended in the most becoming fashion. Sometimes they form little flocks of their own, but never very large ones; they flit swiftly from tree to tree, uttering their shrill chirp of *zi, zi, zi.* They cling to twigs in any position, and for the most part hang swinging with their backs to the earth and their eyes on a level with their feet. Their black, thorn-like beaks are kept constantly probing for minute insects in the bark and under and amongst tufts of lichen. At each peck they must get little enough, and in hard winter weather, when insects are scarce, it no doubt takes them a whole day of hard work to get sufficient food.

In company with the tits there are often golden-crested wrens, seldom more than one or two to each flock of tits, though I have seen as many as eight or ten together. Often one cannot see them, but can hear their unmistakable note. They are far commoner than is supposed, though they vary in numbers from year to year. A cold winter will work havoc among them, only a few surviving to the spring. In southern Kent and Sussex they are to be seen and heard in almost every copse; usually they appear in the company of tits, though they often linger behind when the main flock has gone by.

Goldcrests are extraordinarily tame, the tamest of all our wild birds, or it is perhaps truer to say, the most indifferent to the presence of man. They do not approach man in the same self-interested and comprehending spirit as does a robin, in the hope that his spade will turn up a worm, but in the same way as they might approach a tree, as a natural object neither to be feared nor avoided. I have had them within two feet of my hand; they have glanced at me from time to time and passed on, recognising that I was harmless but of no interest.

The flame-like crest on the males is very bright and easily seen. The feathers of this crest have the same metallic glitter as the feathers of humming-birds, and this is not the only feature they have in common with those tiny, brilliant honey-drinkers of South America. Like humming-birds they can hover, keeping their position in the air, and I have watched them hover with invisibly fast-beating wings opposite the underside of bramble leaves, on which no doubt lurked little groups of aphides. They are seen to their best advantage amongst a setting of bramble leaves, which in winter vary from dead-green to bronze and purple and saffron. They flit delicately amongst the brilliant colours, their own bright crests outshining by far the tints of the leaves.

I have often wondered where such small birds spend the long cold nights of winter. On very cold winters long-tailed-tits have been known to hibernate, some twenty or so together, and pressed into a feathery mass in a hollow branch. They do not usually do this, for they are nearly always to be seen flying about during the day-time. Goldcrests and the smaller tits often roost among the close-set, protecting needles of fir trees, and I have been interested to see how many different sorts of small birds sheltered in haystacks.

There is a large stack not far from my home that stands beside a

tiled outhouse, on the roof of which a great number of sparrows, green-finches, chaffinches and other small birds gather every evening and carry on a very loud conversation about the adventures of the day. There are usually some hundreds all talking at once, and very cheerful and happy. I have watched them, and have noticed how from time to time some of their number would fly across to the stack and disappear under its eaves. Yet the gathering on the roof did not apparently get less; other late arrivals joined up, and others gathered on the ash tree that stands near by. And I have seen a rival meeting of tits of all kinds, with a few hedge-sparrows and goldcrests, in the low-growing brambles and long grasses that are still standing. These also in their turn flew into the stack and disappeared. I have waited till dark, watching them, till they were all abed, and the last good-night twitter had been sounded. On some nights there must have been several hundred birds in that one stack.

A few nights ago I was watching a barn owl fluttering in its silent and ghostly manner over a ploughed field. The flight of these birds always fascinates me. The broad wings are so silent, and beat the air so gently, that it is as though one could feel the softness of the feathers as they pass. I followed him for some distance as he worked to and fro over the field. He did not find anything to pounce on, and after a time he set off for a neighbouring group of haystacks, not my own particular haystack, I am glad to say, and here he fluttered along under the eaves. He settled with a beating of wings to hold him in position, then fluttered on again. I watched him settle again and again, probing into the stack. At last he lifted clear into the air, rose with a magnificent swoop, and dropped to settle on the ridge of the rick, where I could see him with head down tearing at his catch. His meal did not take long, and he was soon back again, beating the side of the stack with his wings while he probed with his head. I could imagine the sight of his large eyes and strong, curved beak to some frightened birdikin or mouse. It may have been mice that he was hunting, but I think it was small birds,

And so, as the winter passes, the flocks are thinned by owls, hawks and hard weather, and with the return of spring the survivors are about as many as the generation of their own parents. The winter communities are broken up when every bird finds his mate and builds a nest, and sets about the all-important-seeming business of rearing a family.

A DRINKER OF BLOOD

Anyone who has seen a rabbit chased by a stoat, or a field-mouse chased by a weasel, must have had his imagination stirred by the evidence in the hunted animal of such extreme terror. This is the same kind of fear which we sometimes experience in dreams, when our limbs are too heavy to move and we are *unable* to save ourselves. A rabbit, hunted by men or dogs, will run for its life, and run swiftly with a very good chance of escape, but a rabbit that is hunted by a stoat will go hunching and limping, as though the paralysis of fear were cramping all its muscles, and at the same time as it limps along it gives pitiful cries of distress. The chase is a short one, for very soon the rabbit will crouch down in a despair of panic to await the swift coming of its pursuer, and while it endures these last dreadful moments of its life it screams continually. The hunted mouse behaves in very much the same way. If it is chased by dog or cat, it will run with instinctive good-sense and swiftness, and even when captured and maimed by a cat still continues to try to escape, and very often does escape, but if it is followed by a weasel, it becomes a ball of hunched limping misery with every hair on end. It goes as one palsied, and cries out in terror as it goes.

What is the cause, we may well ask, of this peculiar behaviour?

I have heard it said that the mouse is hypnotised by the weasel, and that the rabbit is hypnotised by the stoat, but does that really explain anything, unless we can postulate some manner and process of working for the influence from one animal to the other? We must ask how is this hypnotism effected. As the word is usually used, it is meant to connote working of the will. In this sense it can hardly have a meaning in the case of such an animal as the weasel. It also suggests a numbing or controlling of the feelings in the creature which is hypnotised, and this numbing and controlling does appear to be present in the rabbit; but what we must still ask is the nature of the influence producing such an effect, and how does it function?

I have not yet in my reading, or in discussion with other people, found any satisfactory explanation, and so far, as there has been little scientific investigation into phenomena of this kind, one can but look closely at the facts, and then for one's own personal interest and perhaps further advancement, make surmises as to a possible explanation. The main fact is as follows: Certain animals in certain circumstances act in a definite way, as though by instinct, to the detriment of their own, and to the advantage of some other species.

Every countryman knows what disturbance a fox or a cat can make, by its mere presence, amongst blackbirds, thrushes and jays. A cat has but to walk along the bottom of a hedge in springtime, and a dozen or more birds will be scolding at it. An owl has but to appear openly in the daylight, and all the birds in the neighbourhood will gather round to scream and scold. Here we have an obvious antagonism showing itself in a simple and irrational manner. A weasel has much the same effect on the behaviour of small birds such as finches, linnets, etc., but with this difference. The cat or the owl, when mobbed and scolded at, will take very little notice, and will not use this power that it has of exciting enmity for luring its victims within striking range. If a bird in the frenzy of its indignation is foolish enough to come too close to a cat, no doubt that cat will catch it if the opportunity is good enough, but it makes no deliberate gesture which entices the bird nearer. The weasel in contrast to the cat, deliberately evokes in the small birds an even greater excitement than their original hostility has produced, and at the same time it, itself, will become very excited. It performs a kind of dance of invitation; sometimes it will move quickly round and round, and sometimes will remain comparatively still, chattering and quivering. While it does this, the small

birds that are near enough to be within the circle of its charm, flutter nearer and nearer, becoming ever more excited and scolding louder than ever. Nearer and nearer they come until one of them is close enough to be pounced upon and killed.

The weasel has a power over the birds, making them behave in a way detrimental to their interests, but this power when exercised against a mouse seems to be far more potent, and to have upon the mouse quite a different effect. The birds become excited and aggressively angry, they do not show the panic of the mouse, who is obviously trying to escape, but whose limbs fail him.

I have said the mouse is obviously trying to escape, but is what is obvious always what is really happening? If the mouse with all its faculties were trying to escape it would run fast enough. If the birds wanted with all their faculties to avoid the weasel, they would not go nearer to it. The fact of the paralysis and the palsy of fear suggests conflict in the mouse, and are we not justified in asking: Are not part of his instinctive complexes in rebellion? If they were all in harmony with the simple will for life, he would run as he does from a dog or a cat.

We have no definite knowledge of why or how his instincts are in this way perverted, but we are at liberty to surmise, and it seems possible that the fact that the weasel and the stoat are both drinkers of blood may have something to do with this peculiar behaviour of their victims. Is it possible that the blood, which has always been considered as the vehicle of the life, may be, in some way which is at present quite unknown to us, under the influence of the creature which thirsts for it, and that 'the blood which is the life' responds to the stoat or the weasel, even while within the veins of the victims, thus destroying the normal integrity of the instinctive complex for self-preservation? Such an idea is put out as a suggestion, and though it may seem extravagant at first contact, it will not appear so unlikely to anyone who has had the opportunity of closely observing a rabbit and a stoat, or a mouse and a weasel, when associated in their instinctive relationship.

I have myself had several such opportunities, or rather I should say partial opportunities, for one can seldom see the whole drama, but only a part, for on most occasions the stoat or weasel is frightened away by the near presence of a man. Only recently was I able to see at close quarters the actual killing, the behaviour of hunter and victim.

I was in Wiltshire near Swallowcliffe, and was following a foot-track along the downs one misty October morning. The mist was blowing past in soft, cloudy waves, depositing fine drops of water on every small hair of wool on my coat. It grew so thick that I could only see my way by keeping close to the wooden posts that formed the fence on one side of the track; these emerged ghostly grey figures out of the whiteness, and it seemed that the extreme stillness of the heavens had descended with the cloud, and held the earth spell-bound. There were no notes of birds, and no sound was borne upward from the distant and invisible valleys—only the tread of my feet on the turf.

Suddenly I heard the characteristic and peculiar cry of a stoated rabbit. I stood quite still, listening. It came again and nearer, and then from the direction of the wind and blowing mist, there came, out of the mist, the bunched, stricken form of the rabbit. It moved in the usual palsied way, with its hair lifted on its back. Its extreme fear gave it the repellent look of an animal stricken with some disease. Within two paces of where I stood it crouched down and began a long, continuous scream.

My first impulse was to save the rabbit's life and frighten off the stoat, for such terror was almost intolerable. Yet here might be an opportunity of finding out something about that mysterious relation that has so much interested me. And why should I interfere in the course of nature which was so much removed from my own course? Why let my personal feeling prevent a possible revelation of a mystery? And why indeed should I feel sentimental about a rabbit? I had often killed rabbits. We most of us live on the flesh of animals that are killed we know not how, and why should not a stoat be allowed to follow unmolested its natural instincts, which are considerably less life-wasting than human ones?

I stood as still as I was able while the rabbit crouched at my feet still screaming. It had not seen me; I am almost sure it had not seen me, although it was staring straight at me. It was not asking to be saved, but had come by chance to that place and was deep in an unconscious and desperate crisis of its inner life. The stoat, which was still invisible to us both, was already claiming its blood, and the rabbit, with its very essence answering that claim, could go no further.

A few seconds later, the stoat came galloping with supple elongated, streak-like motion. It leaped upon the rabbit, putting its short

arms about the rabbit's neck, and with a cuddling, almost caressing movement, thrust its face down into the soft fur of the nape.

The rabbit screamed more shrilly and threw back its head to that biting embrace. Its eyes were staring and wide as it gazed directly upwards, and I knew that the stoat's small sharp teeth had reached the spinal life, and that the rabbit was now paralysed, and could not, even if its fear were removed, make any further effort.

The stoat, which had climbed on to the rabbit's back, was no longer biting but drinking the blood. The muscles of the neck swelled and contracted, and so also did the muscles of the lean sides. As the rabbit in its terror had not seen me, so also the stoat was completely taken up with the business of drinking. The two creatures seemed mutually involved in that direct communion and transfusion of blood. The joy of killing and the anguish of death were here equated, and as my wonder grew as I watched, it seemed that this union and communion in life and death was a thing having a significance in Nature, and was purposed in that intricate and baffling pattern of things as they appear, and that the incapacity of the rabbit to escape, and all its limping, clumsy panic served a purpose which transcended both the rabbit and the stoat. What that purpose is I do not presume to guess, but the more I look at animals and study their ways, with what I hope is an unprejudiced mind, the more it appears to me that they are not contained wholly within their skins, but involve or are involved with forces of which we have as yet but little understanding.

The stoat was still drinking. Occasionally he moved his position to get better purchase, but his face was hidden in the hollow behind the rabbit's ears. These, as the draught continued, drooped and fell sideways. Then at last the head swayed forward, and the wide-stretched eye-lids relaxed.

Very soon after the rabbit was dead, the stoat's passionate nuzzling changed to a sleek and more complacent satisfaction. He withdrew his mouth from the wound, and lay for a short time on the body of his kill, but soon he returned again for another draught of the fresh blood.

At last he was satisfied, and, withdrawing his muzzle, looked round. His sense of awareness which had been lost during that period of concentration, returned, and looking up he saw me. His black, beady eyes were charged with a quick hostility, and he gave me such a look as a man might have given, if suddenly he were aware that some

stranger had been present during the performance of some intimate rite. He drew back his lips and showed his teeth, then moved away from the body and stood looking at me. He chattered and quivered, and I should very much have liked to know what he was saying. Then with a swift unhaste, he turned and vanished into the mist.

MASTER BUILDERS

In the twelfth century, wild beavers were still to be found living in Scotland and Wales. A century earlier they were inhabiting many English rivers, and extended even as far as the Euphrates. At the present day they survive only in America and Siberia and in one or two out-of-the-way localities in Europe. They are rapidly becoming scarcer, and are threatened by extinction as the result of the trade in their furs.

The most obvious thing about a beaver is his tail. The tail is nearly flat, it is broad and straight and covered with horny scales of a lustrous black. Its principal uses are to elevate or depress the upper portion of the body while the animal is swimming, or to turn it to right or left. While the beaver is swimming on the surface of the water, the tail drags inactive behind, but if, when he is alarmed, he wants to dive, he flicks it up into the air, and so lowers his head, and as he goes into the deeps, he can bring it down with a smack on the surface, which can throw spray two feet into the air, and which makes such a ringing report that all other beavers in the neighbourhood are warned of danger. Mr. Lewis H. Morgan, who has written a most detailed history of these animals, has described this warning sound as being as loud as a pistol shot. It is often followed by several other pistol shots as other beavers follow suit, and as they dive, bring their tails

whacking down into the water. This tail is ten inches long by five and a half broad in a full-grown beaver of forty-two inches long, and it is used, when swimming under water, in the same way as an oar is used when propelling a boat from the stern. A beaver is a good swimmer under water and can hold his breath for nearly fifteen minutes. When on the surface he swims with his hind legs only; his back feet are webbed, thus giving him a good hold on the water; his fore-feet are small with long claws, and are not used in swimming, but are laid close against the under surface of the body.

A beaver, which is in general appearance like a large water-vole, has small, insignificant eyes, and is short-sighted. This no doubt is due to his living so much in the dark. His sense of smell and his hearing are very acute; he is a shy, night-living animal, and is seldom seen in the day-time. His fore-feet, which might almost be called hands, are used for the carrying and manipulating of sticks and stones and pieces of earth; it is with them that he does the greater part of the building of his dams.

The dams are engineering feats undertaken on no small scale. The European beaver does not make dams, but lives very much as the musk rat does, in underground passages whose openings are in river banks beneath the surface of the water. The American beaver has, however, abandoned this simple form of life, and makes dams to form artificial ponds in which he may disport himself and find protection from his enemies, and on whose banks he builds domed fortresses of earth and sticks, where he may winter in safety. These dams are not essential to his existence, and it is a remarkable fact that he should have changed his mode of living from the simple to the artificial.

The building of the dam starts in a small way; sticks are cut and collected and laid horizontally across a stream, and mud and fibrous earth are plastered on the upper or waterside of them. As the dam rises in height, the water is held back, and spreads out on either side. The dam has to be both heightened and broadened, and as the water will run more swiftly at one place than at another, the beavers, in answering to this accidental irregularity, will make their dam curved in one direction or another. Larger sticks are used as the dam becomes larger; these are placed in oblique, slanting positions on the lower side of the structure. On the other side large stones are sometimes placed in amongst the mud to strengthen the base, and more fibrous earth is constantly added. In course of time the dam may

stretch to as much as three hundred feet in width, and be from six to eight feet in height. These large dams are probably of great age, hundreds or even thousands of years old, having been kept in repair by countless generations of beavers. The weight of water in such a dam is very considerable, and to counterbalance this the beavers appear to have hit on a very cunning device. They build a lower dam a little below the upper one, this catches the overflow and makes a smaller pond further down the stream. The water in this lower pond rises and covers the base of the upper dam, and so offers a weight of water, pressing against the lower side, to counterbalance in part the downward pressure from the upper pond. This is a device worthy of an intelligent engineer. The lower pond, it should be noted, is too small to be of any other use to the beavers, and they do not build their lodges round it.

Another kind of dam is sometimes made higher up the valley above the main pond. This is only made when a large amount of water is liable to come rushing down after rainfall and so threaten the main dam. This upper, sheltering dam is raised a foot or more above water-level so as to be able to carry a sudden influx of water.

The water in the main pond is always level with the rim of the dam, and the chief function of the dam is to regulate the depth of water in the pond, and to keep it about two feet above the entrance of the lodges. The earth at the rim of the dam is constantly liable to be displaced, and is as constantly in need of repair. Every night the beavers inspect it and make good the damage which has occurred during the day. They work in a most regular and conscientious manner, and if an artificial breach is made will repair it as soon as they are able.

The trappers engaged in the fur trade make use of this industrious habit of these humble little builders. They make a breach in the dam, and then set their spring gins under water in the place where the beavers are likely to put their feet when they come to repair the dam. The traps are fastened to a slanting stake in such a manner that should the beaver be caught by the hind foot, and should he dive, which is his instinct, he will not be able to rise again, but will miserably drown in his efforts to free himself. Should he be caught by the fore foot, then his heavy weight and the wrenching power he can exert is liable to break the thin bones of the wrist. By twisting round and round he can sever the skin, and is able to tear out the sinews of the arm, leaving them and his claws and skin of the hand behind in

the trap, and so go free. This is the experience, and the comparatively fortunate experience, of hundreds of beavers trapped each year. It affords but an insignificant fraction of the suffering that the fur trade inflicts on animals.

Mr. Lewis Morgan in his book, *The American Beaver and his Work*, deplores the way in which the beavers are being exterminated by the trappers. Like any man who has watched and come to know these fascinating animals, he has a love and a respect for them, and hates to see their pleasant humble virtues, their industry and their love of family, being taken ruthless advantage of, yet he has no false animosity towards the trappers, who are no worse than other men. The trappers follow their trade, and will provide the market so long as there is demand.

The American beaver not only builds dams, but on the shores of his artificial ponds he places his huts or lodges, which offer him protection against any of his enemies, with the exception of man. These lodges are placed half in, half out of water, with two entrance holes, usually from seven to ten feet long, which open under water. One of these is used as an everyday entrance for the beaver and his family; this entrance is usually winding or curved and is about fifteen inches across. The other entrance, which is straight, is used for the introduction of pieces of wood into the lodge. The lodge is a flat, dome-shaped building with walls four to five feet thick, made of earth, mud and sticks. The inner measurements are roughly seven by eight feet across and one foot four inches in height. In these safe places of retreat the beaver family spends the winter; they do not hibernate, but go to and fro to bring wood from their underwater store.

Round each pond there are not usually more than two or three lodges. A dam is started by one pair of beavers; another pair may come and join them as the dam grows. They build their lodges and raise their families, four or five at a birth. They all work at the dam and at the other work of tree-felling, stick-cutting and canal-making, and the storing of winter provisions.

The chief food of the beaver is the bark of trees, not the thick bark of the stem, but the green bark of the branches. In the summer they also eat the leaves and stems of herbs, and are particularly fond of the rhizomes of water-lilies. In the winter they live almost entirely on bark. They will cut down trees with their strong cutting teeth, and will drag or float the branches to their pond, and will there store

them under water, on the floor of the pond close to their lodge. How they get the wood to sink and to remain sunk is unexplained, but there is no doubt that they make these underwater stores.

In the neighbourhood of a pond which has for many years been inhabited by beavers, the trees of the right size and kind have been felled. The beavers have to go far afield for their wood. They find it heavy to drag over the ground, and so they will make canals where water can flow from the pond to the plantations. Up these canals, which are three feet wide, they will float wood for their winter store.

Besides appearing to have such a high order of intelligence, or being, if you prefer, so wisely inspired by instinct, the beaver is a pleasant and friendly animal in himself, and is often kept as a pet by Indians or trappers. He seldom bites and is a safe companion for children. His cry when hurt resembles that of a young baby, and even the trained ears of human mothers can be deceived by the calling of a young beaver. For the sake of his fur this remarkable and charming creature is being made ever scarcer. And it seems a pity, to put it mildly, that whole families of these master builders should be killed by such ruthless methods as the following.

The trapper can find by tapping on the ice where the winter store of wood is hidden. He surrounds this with a ring of stakes, leaving one place open. He fixes a contrivance which will tell him when a beaver enters through this one place. Then he sits and watches. As soon as a beaver has entered the palisade, the trapper blocks the exit. The beaver, unable to return, drowns under the ice. The palisade is again opened, and the female beaver comes to see what has happened to her mate. She also is drowned in the same manner. The young beavers follow and all meet the same fate. When they are all dead, the trapper breaks the ice and collects their fur-clad bodies.

AN AMBIGUOUS BIRTH

Most of the sheep-farmers of north-west Australia tell the same story about the birth of the kangaroo. These men are for the most part good observers of their surroundings and of the creatures with which their work brings them into contact. They know the trails and habits of the reptiles, birds and mammals which find a living on the arid, semi-desert plateaux of the north-west. As field naturalists they are not to be despised, and I have again and again found how penetrating and accurate their observations have been. But the story they told, and it was always the same story, about the birth of the kangaroo left me sceptical. Not till the proof was presented to my unbelieving eyes, would I believe there was anything in it, and even then I was sceptical. I had been taught otherwise, I knew that the kangaroo, like other mammals, had a uterus, indeed I knew that she had two, and that although the young kangaroo was born, like other marsupials, at an early stage, yet I knew that the young were born out of the mother's body as other mammals are born, and that they were certainly not budded from the mother's abdomen, as these men maintained that they were budded, and as indeed the sight of the dead mother kangaroo with the yet living young ones would persuade my unwilling reason to believe that they were budded like so many young polyps on a stem. Without a doubt they were attached to their

mother's body within the pouch. The flesh was continuous between their heads and the skin of the maternal abdomen. It was impossible to pull them off. They were indeed as the sheep-farmers had told me, like buds. And when one of the unhappy youngsters was pulled off, the tissues broke revealing the torn blood-vessels which went between the mother and the young. There was no separation here, and no wonder that anyone should suppose that the young creatures had budded out, as my informants had told me.

On looking more closely at the young kangaroos, which in this case were not more than two inches long, one could see that the lips were enormously swollen, and it was through these enlarged lips that the young creature was fastened to the mother's body, that the blood-vessels passed. They formed in fact a kind of post-natal placenta.

In spite of the fact of this attachment through the lips, my sheep-farming informants had in this case been at fault. The young kangaroo is not budded in the mother's pouch, as they believe, but is born in the ordinary way; it is born at a very much earlier stage than the young of the placental mammals. When the young kangaroo first leaves the mother's body, it is scarcely more than an inch long. It is in a very early stage of development, but it has enormously developed prehensile lips.

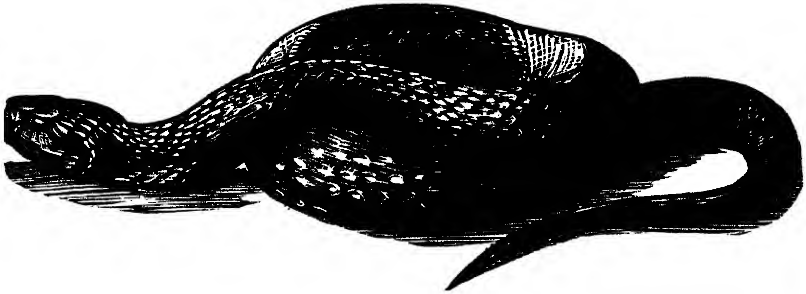
After it has been born, and while it still lies helpless on the ground, the mother kangaroo picks it up with her lips, and places it in the pouch, on one of the sebaceous glands which later function as milk glands. The young animal fastens on, and in a short time the skin breaks down between mother and offspring, and there is established a second intimate relationship in which the blood of the parent brings nourishment to the young. For several months this state of attachment continues, and no doubt it was during such periods, when the young and the mother were of one continuous flesh, that the Australian farmers and bushmen had made their observations. The young kangaroos *appeared* to be budded from the maternal abdomen, and nothing that I could say would shake them from their belief.

As the weeks pass, and the young kangaroos grow in strength and size, the lips become comparatively less large and after a time an abscess layer is formed, and the tissue which connects the parent and the young breaks down. A new stage of life now develops, and after this second separation from the parent, the young kangaroo lives by the sucking of milk from the mammary glands. All this time of

course it lives in the pouch, and remains a frequenter of the pouch long after the time when it can leap in and out, and partake of adult food. It is astonishing indeed to see how large the young kangaroo can be before adopting a completely independent life.

This method of birth, observed and recorded in the case of the kangaroo and wallaby, is probably repeated in all other marsupials. I have often seen marsupial mice and bandicoots with young in their pouches, but the young have always happened to be in the later stages of their development. I have never seen them in the 'bud' stage. They must be extremely minute, if the newly-born kangaroo, a creature which stands five feet high when mature, is barely an inch long. How much smaller must be the newly-born mice?

The parallel developments within the marsupials and the placentate mammals is a phenomenon which must strike any observer as remarkable. Here are two quite different groups of animals which have not only essential differences in the manner of birth, but also in the formation of their bones. It is probable that the marsupials mark an earlier stage of evolution and that they have been replaced by the placentate mammals in most localities. The marsupials are still found in Australia, Tasmania and South America, where they appear to have been protected from the competition of the more lately evolved forms. It is indeed remarkable that both groups of animals are divided into sub-groups which show marked parallel resemblances. Among the marsupials there are the kangaroos and wallabies, which are herb-eaters and show a marked resemblance to the ungulates; there is the Tasmanian wolf, showing a marked correspondence with the carnivores; there are the marsupial mice and rats, which in outward appearance are so similar to the rodents as to be hardly distinguishable, when they are running wild, from the placental mice and rats, and there are insect-eating creatures, such as bandicoots, which present a parallel resemblance to such insect-eaters as the hedgehog. Is it not an extraordinary fact that the same kind of outward forms, the same habits of life should distinguish corresponding groups within these larger groups which have been evolved or created at separate times and quite distinct from one another? Does this not suggest that the same final cause, or some similar factors of the same final cause, was determining these parallel lines of development?



VITALITY IN SNAKES

One of the most vivid recollections of my childhood is of a drive through the Tasmanian bush on the way to church. My mother and myself were on a visit to relatives who had a large farm near Launceston, church-going was an important event, never to be missed, and the whole household turned out in two buggies for the five-mile drive through the bush. I was on the back seat of the second buggy with two other children. Tim Watson, my cousin, who must have been about twenty at the time, was driving, and my mother was sitting beside him. When we had gone the greater part of the way, my mother, who was always quick at seeing wild things in the bush, saw a large, black snake which was lying sunning itself near the track. Black snakes are poisonous and are regarded by all true bushmen as the enemies of mankind. My cousin dropped the reins and jumped down with his whip, and began striking at the snake, which at first tried to make off, but very soon turned to defend itself. We children on the back seat soon tumbled off, and, picking up what sticks we could lay hands on, tried to help. My mother had all she could do to control the horse who became infected by the general excitement.

The contest lasted a good five minutes before the snake's back was broken. Tim managed to get a forked stick across the back of its head and then drove the blade of his pocket knife through the base of its skull. But the snake was by no means dead. Tim said it was not possible to kill snakes completely, and as this was an exceptionally large

specimen, and he did not want to spoil the skin by knocking it about, he pinned its head to the bottom-boards of the buggy. We drove on to church with the stimulating feeling of the snake's coils writhing every now and then about our ankles.

After the service all the congregation and the parson came to see the snake which appeared as active as ever, though its head was still pinned to the boards of the buggy. The general opinion was that this was the largest black snake that had ever been killed in the district. We were very pleased and proud of ourselves and, after dinner, we children turned out to help with the skinning.

I remember the thrill of awe and revulsion which I felt when I was shown the fangs, with their inflated bags of poison at the base. Tim squeezed the poison out for us to see. Then came the skinning and the second and the third thrill. The flesh was astonishingly white, with a queer iridescence in the muscles which moved in rhythmical convulsions as the skin was peeled from them. I have later seen exactly the same movement, though even more pronounced, in the flesh of a turtle. Steaks of turtle flesh I have seen move themselves from place to place by this rhythmical convulsion. The other thrill was afforded by the undigested or partially digested animals which came out of its stomach. Two complete kangaroo rats and a partially digested chicken. This latter surprised us for it was not of a breed that could be identified on any of the neighbouring farms.

At last the skin was clear of the carcass, and the white-fleshed and still-moving body was thrown on to the rubbish heap. The next morning I went back, fascinated, to look at it, and was relieved to see that it was at last properly dead with no lingering signs of vitality.

And yet, strange, almost incredible to relate, there was a part of the snake which still harboured some remnant of life, which was to endure for many years to come.

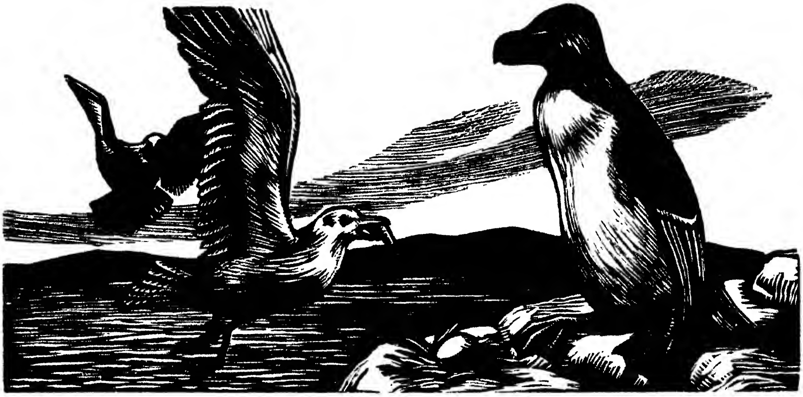
The skin, when it was peeled off, was stretched and nailed to a plank, inner side uppermost. This was dusted with pepper and salt and then painted with arsenical soap and left to dry in the sun. It measured nearly eight feet, and was considered worthy of being subsequently sent to a taxidermist in Hobart to be mounted on green baize, and was then given to my mother as a memento of her visit to Tasmania. It travelled back to England with us, and for many years hung on the wall of our dining-room. I cannot say for sure how long we kept it, or what ultimately happened to it, but I know that we had

it for ten years at least, and all that time it gave a seasonal affirmation of its undying vitality.

Every year it shed a thin, gauze-like skin of outer scales.

It is well known that snakes shed their skins each spring, and most people have found the thin, dry, brown fabric of the cast skin caught amidst thick grasses or amongst briars, but it is not so well known that the skin of a snake, even though detached from its body and mounted on a cloth and hung up in a sitting-room, will also make an effort to repeat this seasonal change year after year at the appropriate time. Thin, very thin, flake-like scales are formed on every scale of the skin, even those over the eye-scales are formed, and these, each year, have to be dusted off, if the skin is not going to look too disgracefully shabby.

What sort of life is this which continues far away from and quite independent of the main part of the body of the creature? What is the life which persists in this mere portion? How can it survive the drying in the sun, the dressing of pepper and salt and the arsenical soap? What is there to nourish it? From where can it gain its impulse towards this divesting itself of that which would by this time be the old and faded covering, had the animal remained within the normal rhythm of its existence? Can this activity be a mere chemico-physical reaction? And if so, to what? What is life? Biologists and philosophers of all periods have offered various suggestions, and psychologists tell us in general terms that life is a state of equilibrium maintained between opposing forces of creation and destruction, and this perhaps is as satisfactory a definition as one can find for what remains unknown and still baffling to the investigations of science. But what, in this case, are the opposing forces? And what is the impulse which urges this detached, and, in all other respects, dead skin, to show this symptom of life?



SEA BIRDS

There are cliffs in south Devon where razorbills make their nests, or it would be more correct to say, lay their eggs, for they make no nests, but lay their large, various-coloured eggs on the cliff-ledges. In late July and even early August, one may still see the young birds and sometimes the unhatched eggs perched on their craggy nurseries, and the older birds busy with feeding and incubating. At Woody Bay there is a trackway through one of those wind-swept oak woods which cling to the cliff face, which leads down to a good vantage point, from where it is possible to observe the birds without disturbing too much their peace of mind.

The razorbill and its close relative the guillemot are essentially sea-going and sea-living birds, which only visit the land for the breeding season. They incubate only one egg at a time, but when their first nursling is launched into the world, they will come back to the rock-ledge and lay a second egg. The parent birds do not have the appearance of strong fliers, their wings are very short and they have to move them very fast, and when they leave the water, they do so with a great splashing and paddling of the legs. When once fairly in the air, they rise in gradual ascent with a whirring of pinions. On the land they are clumsy walkers, but in the water swim marvellously well, using their short wings as paddles when they dive.

They feed their young on small fishes, and it has always seemed to

me a bit of a mystery how they manage to hold so many in their beaks at the same time. I have seen birds with already two or three fish in their beaks continue diving for more, and ultimately come up with five or six live fish. How is it that they manage to get more fish in, without letting go of those which they have already caught? But manage it they do, and arrive at regular intervals with their beaks stuffed full of wriggling fishlets. Seldom do they let any escape, except when attacked on their way to the nursery by the thieving gulls, and then it is an amusing sight to see how the gulls dive down and swoop and catch the falling fish in the air before it can touch the sea.

When I have been watching the razorbills with their young, I have wondered how the young birds get from their high ledges of rock, often eighty or a hundred feet above the sea, down to the water. They certainly cannot fly there, and if they were just to lurch over the edge, they would in many cases fall on to rocks and inevitably be killed. The Devon fishermen tell me that they have seen the young birds carried on the backs of their mothers, and this I think must be the case. I have waited long hoping to see this sight, but never has my patience been rewarded. It would be a remarkable sight, and a feat which would demand a good deal of skill, for the young bird is a considerable size at the time it takes to the water, and would be no light burden for a bird with such short wings. And how is it to keep hold on the sleek, downy back of its mother?

While waiting to see the descent of the young razorbills, I have watched the gulls exhibiting their supreme mastery of the art of flight. There is a wonder and fascination in watching them. They can at times appear to remain quite motionless in the air, and will hang stationary, with their wide yellow eyes fixed on me, then, with the least inclination of a wing, will swoop and fall and be a hundred yards distant in what seems but a second of time. They are as much creatures of the air as the razorbills are creatures of the water, and yet they are very much at home on the sea also, and like flecks of foam float and toss between the waves. When they are flying they often seem to be dreaming in their flight, and if seen far enough off, appear quite forgetful of the earth, but at a closer view their yellow eyes are filled with hungry intelligence, continually on the look-out for something to eat. They are as greedy and rapacious as the strong hooked beak and the low forehead which supports it would lead one to suppose.

Among the talus of tumbled rocks near the cliff base there are usually rock-pipits flitting to and fro amongst the boulders. As the warm August afternoon passes, they seem to bear a resemblance in their wayward movements to one's lighter fancies, which are pleasantly doing something, nothing very important, but sufficient, as they flit for hour after hour in and out amongst the rocks. Only occasionally one or other makes a flight into the upper air, and then almost invariably it is attacked at once by one of the gulls. I have seen them caught and eaten, but usually they escape. They are small and can dodge quicker than the gulls, and make sharper turns. As a butterfly can usually escape from a sparrow, so do the pipits escape from the gulls; they dart back to the shelter of their familiar rocks, and as soon as they are near them once more, the gulls give up the pursuit, and in a few seconds they have forgotten their danger and are back at their games amongst the boulders as though nothing had happened.

One of the most remarkable of sea birds is the storm petrel. These small, frail-looking birds, which look like long-winged house-martins, can be met far out in the Atlantic, where there are few if any other birds. They have a habit of following ships, not, I believe, as gulls do to pick up the scraps which are thrown overboard, but to catch the sea creatures, which are churned up by the passing of the ship. I have watched one or two of these little birds following for day after day in the wake of the ship in which I have been travelling. They seem always to be on the wing, and never have I seen them resting on the water, though I think there must be times when they pause and rest. They fly very close to the waves, just skimming them, and often they paddle with a quick motion with their webbed feet as they fly. This characteristic action has won for them the name of 'Little Peters' trying to walk on the waves. It is a small sooty bird with a white patch above and below the base of the tail. In the storm petrel the tail is square and not forked as in some allied species. The flight is strong and erratic, much resembling a swallow's, and with the same assurance as a swallow it flies close to the water, and can catch, as it flies, without alighting, small fragments from the surface and scoop up any oily matter. I have never been fortunate enough to see these birds swimming, but I am told that they swim when the waves are too rough for them to fly over them easily. Then it is they will sometimes rest themselves in this way. But they rest very little, and watching them day after day and hour after hour one wonders, do these and

other sea birds ever sleep? Gulls I have seen with eyes closed, floating on the waves, taking what may be momentary naps, but petrels seem ever-restless and ever-tireless.

Another bird which would appear to be possessed of an almost infinite energy is the albatross. I have watched an albatross all the way from The Cape to Australia. He followed our ship floating in the air in the easiest manner at about fourteen knots an hour. At this pace he did not seem to move in any way that could be considered a deliberate form of flight. He just stayed there, suspended in the air and travelled with us. If it should happen that his attention was caught by some object on the sea, he would slope his great wings, and be away a quarter-mile distant, and with the next movement, turn and be back again, and in his place above the mast, watching; or he would drop to the water, and would be left behind while engaged in the business of eating some fragment thrown overboard from the galley, and then with an easy and marvellous speed overtake us again. All night he would fly close beside us, the white expanse of his wings like a ghost in the darkness, and the next morning would be in his place, flying with the same untiring ease and little movement. I do not think he slept. Or did he perhaps sleep as he flew?

THAT SEA BEAST

That sea beast
Leviathan, which God of all his works
Created hugest that swims the ocean stream.
'Paradise Lost.'

The whale, and let us take the noblest of its kind, the cachalot, is the largest living animal. A full-grown sperm whale can be from eighty to ninety feet in length, and nearly forty feet in fullest circumference. A specimen of this size would weigh about ninety tons, and would considerably out-weigh the combined population of a whole village of one thousand one hundred inhabitants. This enormous creature is no fish, although living entirely in the sea. It is a warm-blooded, air-breathing mammal, and it is supposed that his early, ancestral forms had their origins on the land, and gradually became adapted to a marine life. Vestigial hind-limb girdles are found embedded in the flesh; the fore-limbs are, of course, represented by the swimming flippers.

The whole body of the whale is covered, as with a skin, by blubber, which is something of the consistency of firm, close-grained beef, but tougher, more elastic and compact, and ranges from eight or ten to fifteen inches in thickness. It is from this blubber that the oil is extracted. A large whale will yield from this blanket of blubber close

on a hundred barrels, and it is by reason of this close blanketing of the body that the whale is enabled to keep himself comfortable in all weathers in all seas; by this his warm blood is kept at an even temperature. On the outer surface of the blubber there is a thin, transparent substance, covering the whole body; this is as soft as satin and as flexible. It can be scraped off, and when dried still retains its transparent quality, though it becomes, as it dries, hard and brittle.

The whale's head occupies a full third of the body's length. The eyes are set far back and low down near to the angle of the jaw. They are comparatively small for so vast a head, and are no larger than a horse's eyes, and are without lashes. They are set one on each side with all the bulk of the head between them, and it is plain from their position that the whale cannot see what is ahead of him, nor what is behind him. Their position corresponds to that of a man's ears, and if we imagine what the world would look like if our eyes were in our ears, then we may get an idea of how things may appear to a whale. A whale must have two fields of vision which are both quite different; he must have the power to look at two different things at once. This must be either perplexing, or else he must have a mental power more comprehensive and subtle than man's, which enables him to turn his attention on two distinct prospects, one on one side of him, and the other in an exactly opposite direction. The ear is so small that it is extremely difficult to see. There is no external leaf, only a tiny hole which is situated a little behind the eye. The whale is dumb, and can make no sound save the rasping of his breath through the spiracle. He has no nose, and his spout-hole, which is his outward breathing organ is at the top of his head. There is no direct connection between the wind-pipe and the mouth, and on this account he can stay with his mouth open under water without fear of water getting into his breathing organs. Sometimes the cachalot can be seen through clear water hanging supine with his lower jaw dropped at right angles to his body, and mouth wide open. The jaw which is placed completely under the head is, in a large whale, fifteen feet long with forty-two teeth in it. This view of the gaping mouth must be truly appalling. The front of the whale's face is quite featureless, it is a dead, blind wall without a single organ or prominence of any sort whatever. This upper portion of the head is encased in blubber like the rest of the body, but here, though not so thick, it is of harder, tougher nature; it is so tough and hard, though boneless, that the 'sharpest lance darted

from the strongest human arm impotently rebounds from it. It is as though the forehead of the sperm whale is paved with horses' hooves.' Behind this blank, featureless forehead is a great unctuous mass wholly free from any bony structure. The lower part is an immense honeycomb of oil formed by the crossing and recrossing of tough, elastic, white fibres; the upper part, known as the *case*, is a great tank of spermaceti, which in the living whale is a pure, limpid liquid. This case covers the entire length of the head, some twenty feet or more.

Behind this enormous oil tank in the forehead is the brain, contained in a comparatively small cavity in the skull. Compared with the huge bulk of the whale, the brain is small, but it is by no means small in itself. It is considerably larger than a man's brain. Physiologists tell us that the size of a brain determines the intelligence—size and the amount of convolutions which exist in the surface folds. A whale's brain is even more deeply convoluted than a man's, so that both by size and convolutions the brain of the cachalot would indicate a high state of intelligence. Professor Adam Sedgwick when he lectured on the whale would never pass over these points. 'Had the whale,' he used to say, 'a means of recording his experience, then he would have been the master of the world. Possessing a better brain than man, bigger, more convoluted, he lacks only the reversible digit, the thumb which can grasp and hold a tool.' Had the whale but the reversible digit, then such a civilisation would have arisen from the sea as would be beyond the dreams of puny man. . . . But perhaps not . . . perhaps the greater intelligence of the whale is of a Buddhistic or Yogi-like nature, and the vast monster, when he is seen submerged and stationary, with his jaw drooping and mouth agape, may be then deep sunk in meditation, with all his bound-up and mute imaginings made calm and still, and the immense vigour and vital strength of him lulled into harmony with the peace which is eternal. What visions of the soul's profundity may then be his?

Herman Melville, who comes as near to knowing the whale in a sympathetic and imaginative manner as any man has done, describes a scene off Java Head, when a whaling ship came in contact with a vast herd of sperm whales. The three boats were lowered and started on their work of slaughter. One of the boats was dragged by a harpooned whale into the heart of the shoal. Here the hunted whale made his escape from the iron, and the men, awed by the number of whales, which were on all sides of them, held their hands from further

attack. Melville describes how like household dogs the whales came snuffing round them, right up to the gunwales, and touching them; till it almost seemed as though some spell had suddenly domesticated them. And he continues:

'But far beneath this wondrous world upon the surface, another and still stranger world met our eyes as we gazed over the side. For suspended in those watery vaults, floated the forms of the nursing mothers of the whales, and those that by their enormous girth seemed shortly to become mothers. . . . and as human infants while suckling will calmly and fixedly gaze away from the breast, as if leading two different lives at the time; and while yet drawing mortal nourishment, be still spiritually feasting upon some unearthly reminiscence; even so did the young of these whales seem looking up towards us, but not at us, as if we were but a bit of gulfweed in their new-born sight. Floating on their sides, the mothers also seemed quietly eyeing us. One of these little infants, that from certain queer tokens seemed hardly a day old, might have measured some fourteen feet in length, and some six feet in girth. He was a little frisky; though his body seemed scarce yet recovered from that irksome position it had so lately occupied in the maternal reticule; where, tail to head, and all ready for the final spring, the unborn whale lies bent like a Tartar's bow. The delicate side-fins, and the palms of his flukes, still freshly retained the plaited crumpled appearance of a baby's ears newly arrived from foreign parts.'

If a seaman, whose business amongst the whales was but to hunt and kill, could see thus much, and paint so charming a picture, what might not a naturalist, or an educationist, or even a psychologist—what might he not learn of these monsters of the deep, if once he could establish communication with the intelligences which are possessed of those highly convoluted brains, and whose vast bodies lack but the reversible digit to be masters of creation?

HANDS AND TOOLS

Most of the preceding accounts of life histories have been chosen as presenting cases of complicated adaptation. In these examples, where a highly developed instinct determines the behaviour, we see the bodily form as the explicit expression of function, and the animal, together with its activities, making a strictly limited unity within a perfected pattern. When considering such elaborate associations, as for example that of the yucca and the *Pronuba* or that of the sea slug and the coelenterates on which it feeds, we find it hard to imagine, as the older biologists have done, that these highly-specialised and interdependent characteristics are in their present state of inter-relationship of form and function, because they have become so either through adaptation to environment or through the action of natural selection, but rather that they have become what they are as the result of inherent final causes. Aristotle has spoken of these final causes as an *entelechy*, which word literally translated means a complete reality or actuality. This entelechy appears in the cases which have been described as an innate wisdom, finding its limits within the morphological, physiological pattern that the animal life-history presents—a wisdom which has penetrated deeply into the organism, and has determined the behaviour of the creature and also its development, for the organs have become what they are in accordance with the *idea* of what the animal is. In this chapter, it will be worth while, for those who have read so far, to compare the human hand and its functions with those highly specialised organs of the

instinctive creatures already described and with the functions which these latter perform. From such a comparison it will be seen that a different kind of final cause is here in operation.

First if we compare the human hand with the homologous extremities which take its place among the mammals, we will at once perceive that it is less well equipped for its tasks, or rather for any *one* of the tasks which the animal's extremities have been modified to perform. The paw of a lion or a cat, armed with formidable talons, is better adapted for tearing and holding; the hoof of a horse is better adapted for running, the foot of a mole for digging; the sloth's climbing foot is better adapted for holding to branches, the wing of a bat for flying, and the flipper of a seal for swimming. All these organs are far more highly modified for their purposes than is the human hand, and each is possessed of a perfection which the hand lacks. If then, for the moment, we neglect its latent possibilities, we see that considered as a tool, formed for a particular task, the human hand is more imperfect than are the homologous organs of other creatures. It can also be seen that in its physical form the human hand can be taken as a starting point for all the other modifications. The animal organs can be regarded as tools which have become specialised; only the hand in its unspecialised state includes the potentialities of all these in itself; and this, not because it has been developed beyond all others, but because it had remained behind all others. It has avoided any of the characteristics of finality, any extravagant metamorphosis which would limit its adaptability. Because of this arrested physical development it retains the versatility which enables it to make use of tools, which it can fashion at the instigation of the mind. For the very reason that human hands are so undeveloped, the human mind has been compelled to devise tools to replace the tools which animals have found in their own bodies. To be able to imitate a flipper, man has lengthened his hands into paddles or oars. The hook of a climbing iron is very similar to the curved claw of a sloth. The boat-hook, which man has devised for holding fast, is very similar to the claw on the foot of a bee. Pincers are similar in design and action to the mandibles of insects, and in many other ways, consciously or unconsciously, man has substituted manufactured tools which are equivalent to those which are incorporated in the bodies of animals. An investigation of animal weapons will soon reveal that the greater the perfection of these tools, the more limited is their purpose;

the human hand alone remains adaptable to many uses, and this because it is less specialised than any animal limb.

This argument that the human hand is less developed than the extremities of animals is supported by the facts of embryology. If the embryos of a man, a dog, a rabbit, a bat and a bird, are observed in their early stages, it can be seen how hand-like the anterior limb is. The mature form only gradually develops from its hand-like origin. The paw and the wing are final stages, perfected tools for running and flight. The hand of man remains nearest to the embryo form, undeveloped and foetal. A stopping short, a retardation is the characteristic, the distinction of the human organ.

The paleontological record, in so far as it is at all complete, demonstrates the same fact, namely that the highly specialised tools of mammals have been developed from an archetypal five-fingered hand. The well-known and oft-quoted story of the development of the horse is an illustration of this. The contemporary horse has only the third member of the radial five-toes' system to run with. It only uses the abnormally lengthened middle finger. The other radii, as the ancestral chain shows, have gradually degenerated. The primal forms (*Eohippus* and *Hyracotherium*) had the four radial toes still fully developed, and with the fifth hind-toe rudimentary. No one of the fore toes was lengthened into a special running limb. The development has here been most obviously away from the archetypal pattern, to which the human hand still bears such close resemblance.

Not only the hands of the human being but the head retains its primitive condition, and its resemblance to the foetal head. The human head stands erect and aloof upon its neck, and does not participate in the physical activities of its possessor, as does the animal's head. The animal's head is invariably used as a tool of some sort or other—the elephant's and the giraffe's for reaching up towards and for plucking food, the whale's for parting the waters, the bull's and the stag's and the goat's for fighting, the beaver's as wielder of its chisel-like teeth, and so on. Even the birds, which have the same upright carriage, and carry their heads erect, use their heads as tools for cleaning their feathers and as weapons for pecking and tearing and for cleaving the air. This instrumental nature of a bird's head is particularly marked in the case of the parrot with its pair of tongs, and in the case of the woodpecker with hammer and axe. Man alone holds his head, reserved and aloof. The modification of the animal's head

into a tool, for physical operation on its environment, has taken from it the universality which distinguishes the human head, and what it sacrifices in universality it gains in physical efficiency. The embryo of a chimpanzee and also a young chimpanzee has a skull and a face of human shape, with the features flat in the face, the skull domed and rounded; but as it develops from childhood towards adolescence the crown of the skull is raised into a bony ridge, which joins other ridges at the back which come up from the temples to meet it; the mouth and the lower jaw come forward to form an animal jowl, and the rims of the eye-sockets thicken, and the eyebrows swell in front of a receding forehead. This change from the primitive and foetal condition to that of typical adult animal takes place in the course of five years, a time in which the face of a child has changed very little. The animal's visage has become modified into a tool and a weapon, while the human face has remained very near the archetypal form. The human head does not develop as does the animal's but achieves its significance by keeping its pristine shape.

But what about the brain, which is so far more developed in man than in the animals?

It is both obvious and true that man has a more highly developed brain than any animal, and it has been argued by a Dutch anatomist, L. Blok in *Das Problem der Menschwerdung*, that the brain of man has been able to continue its development further than the brains of animals precisely because it retains its foetal proportions. He demonstrates that the axis of every vertebrate embryo is considerably curved at the cranial extremity, and turned back on itself like the handle of a walking-stick. This curve retains, in man, its characteristic form throughout life, and this is the reason, argues Herr Blok, why a man's nose, which is the organ adjoining the olfactory lobes, which are the anterior termination of the brain, points in a direction almost parallel to the axis of his body. In the majority of mammals on the other hand a straightening out of this curve takes place during the later part of the foetal period. The head and brain of the higher animals begin with the characteristic human proportions, but have not retained them. Only the human body is stamped so characteristically with the continuance of the foetal conditions.

From these considerations it would seem that a capacity to hold back from the developments of specialisation, which have been followed by animals, marks man's superiority. Because he has remained

nearer to a primal, and perhaps more plastic condition, he is able to follow his way towards that final cause, to use Aristotle's phrase, which conditions his becoming. What this final cause may be, science does not pretend to answer, though the words of religion which speak of 'the foxes having holes and the birds of the air having nests, and the Son of Man having nowhere to lay His head', speaks with no uncertainty of these facts.

The comparison which finally presents itself between such highly specialised creatures as the *Asmidea* or the sea-slugs, and man, who is born helpless into the world, and who has such comparatively weak instincts to guide him, suggests that quite different kinds of life-organisations are here at work. And man after contemplating the lower animals and the exact and limited wisdom which is expressed in their behaviour, and then looking at his own hands, which are soft and unarmed, and fit only for the plucking of fruit or the weaving of leaves or stems, is justified in the thought that in their nakedness and imperfection lies his superiority. He is not, as they are, in bondage to a body already so strictly adapted to conditions. He can say to himself: I am less complete within myself than are the animals, and my body, uncovered by any protection, can in no way prophesy what shall be my destiny. In all other creatures I perceive limited capacities, which inevitably accompany their development, for how could the behaviour of the animals be at variance with their form? No wisdom so perfected as theirs has penetrated into my structure. I am without wisdom, but of unlimited capacities.

NURSERIES, NURSES AND MIDWIVES

That tadpoles, if developing in their natural surroundings, usually turn into frogs is a fact well known to any country-bred child, and we all know the great number of eggs that the mother frog is capable of producing. Anyone with but small powers of observation will have noticed how careless the frogs are in laying their eggs, how that they often lay in but shallow pools which are destined early to dry up, and where their eggs or the newly emerged tadpoles perish. The frogs which produce such immense numbers of progeny can afford to lose a large proportion of their offspring, secure in the fact that if but a comparative few survive, these few will be sufficient.

This prodigality and carelessness of habit is not however the rule with many other species of frogs, which appear to act with care and forethought for the well-being of their young, and which will make sheltered and adequate nurseries for their descendants, even though they do not stay to watch over their welfare. There is a tree frog, living in Brazil (*Hyla faber*), which protects its progeny by building basin-shaped nurseries in the shallow waters of the edges of ponds. The female frog scoops out the mud to the depth of three or four inches; with the mud she has removed from the bowl of the basin she builds a circular parapet, which rises above the surface of the water. She uses her webbed hands for smoothing the inside of the mud wall

and her abdomen, which she flops up and down, for smoothing the bottom of the basin. These nurseries, spotted about the borders of ponds, look like the craters of tiny, extinct volcanoes, and measure nearly a foot each in diameter. In each of these nurseries the female frog lays a few eggs. The young tadpoles in their early stages are protected by the walls of the craters from the attacks of aquatic insects and fish. As the larvae grow older and larger, the walls of the nursery become gradually disintegrated by the action of wind and water, and the growing tadpoles escape to take their chances in the larger world of the pond.

Another frog, this time in Japan (*Rhacophorus schlegelii*), makes her nursery in a safer place and more distantly removed from the dangers of exposure. The male and the female together bury themselves in the damp earth on the edge of a ditch or stream, and there make an excavation placed at a few inches above the water level. They take some time and trouble in smoothing the walls of this chamber, and in doing so block up the entrance through which they have come. When they are completely enclosed in their smooth-walled retreat, the female produces from her vent a secretion, which by quick movements of her feet she beats up into a froth of slime and air-bubbles. Into this she lays her eggs. The male who all this while has been clinging to her back, impregnates the eggs as they enter the slimy agglomeration. The pair then separate and make their way out of the marriage chamber, which is now destined to serve as a nursery for the young. They do not, however, go out the way they came in, namely upwards towards the surface of the ground, but they go downwards, obliquely towards the water of the stream. In this action they would *seem* to show great forethought for the welfare of their tadpoles, and would *seem* also to be governed by an understanding of direction. This tunnel which they now make is utilised later by the larvae, when the time is come when they shall escape from the safety of their nursery. When the eggs hatch, the tadpoles find themselves completely protected; they live in the frothy mass surrounding them, breathing the moist air-bubbles which are there entangled. By the time they are old enough to seek a wider sphere of activity, the froth and bubbles of the original nest have broken down into a kind of slime, which assists them to slither down the tunnel into the stream.

A similar nest, made of froth, is used by several other species of

frogs as a safe harbourage for their young. Tree frogs in South America often attach their nests to leaves, which by the slime are held together. Such nests are usually made over pools of water. When the eggs hatch, the young tadpoles wriggle about in the protecting agglomeration of air-bubbles and slime. When they are older, they drop off the trees into the pools beneath, and in the water finish their metamorphosis in the usual way. The eggs of these tree frogs, that make nests or nurseries, are far fewer than those of the more careless species, and they are also much richer in yolk. More of substance can be given to them, since their survival-chance is greater.

Another form of nursery into which are introduced only about a dozen eggs is made by a New Guinea species of frog (*Phrynixalus biroi*). In this case the eggs are enclosed in a transparent membrane secreted by the mother. This capsule lies in water while the development of the young takes place within the egg. No free tadpole stage has been observed, the young tadpoles lying curled up within the eggs, breathing through their tails, and without any normal development of gills. This breathing through the tail is not an uncommon habit amongst the tadpoles of tree frogs. Several different species in different parts of the world develop within the egg and use their tails as breathing organs.

The habit of making nurseries and then abandoning them and their contained nurslings to chance is one method followed by a fairly large section of the frog population of the world. Other species, instead of making nurseries, become themselves the nurses of their broods. There is a small South American frog (*Denerobates trivittatus*) which carries its tadpoles on its back. These tadpoles are very similar to those which we see in ponds in England; they hold on to their parents with their prehensile lips, and press their flat, moist abdomens close against their backs. These frogs spawn in water, the parent frogs remaining in the neighbourhood till the eggs are hatched. The little tadpoles crawl on to their backs for the purpose, apparently, of being transferred from pond to pond. No doubt the action is entirely automatic, and it would be interesting to know what conditions prompted this action, and whether the parent frog when loaded up with its burden of tadpoles invariably made its way to another locality. In a tropical region, where pools are liable to dry up quickly, such an adaptation would certainly be useful .It argues, however, an extraordinary degree of correlation between the climatic

conditions, the behaviour of the parent frogs and the responsive behaviour of the tadpoles.

Another light variant of this behaviour-pattern is provided by a mountain-dwelling frog from the Seychelles (*Sooglossus schellensis*). At an altitude of five thousand feet there is little still water to be found. The female lays her eggs amongst leaves. As soon as these are hatched, the tadpoles wriggle themselves on to the back of the male frog, and there retain their position partly by suction and partly by the help of a gummy secretion produced by the father. These tadpoles appear to live during their larval development on the parent's back, and are not there merely for the purpose of transportation.

Such frogs as those already described may be considered as the nurses of their offspring, in that they either provide them with nurseries or nests or, carrying them about upon their persons, contribute to their safety or convenience. There is, however, a further degree of solicitude that frogs exhibit towards their young. The Midwife Toad (*Alytes obstetricans*) was discovered in France in the very act which has given to it its name. And it is a remarkable fact that a creature of such primitive development as a frog should show such a seemingly high degree of solicitude for its young, as does this animal. In this case, as in those already described, it is wiser to assume that the behaviour is almost entirely automatic, though that does not make it any the less wonderful. When we regard such life-histories, we are forced to ask whether such behaviour is the result of fortuitous variations or mutations in their response to environment, or whether some external or internal directive spirit is in these various and peculiar ways making itself manifest.

The male of the midwife toad seizes the female round the waist, after the usual manner of toads and frogs. With appropriate movements of his toes, he stimulates her to stretch out her legs, then places his own hind legs between them and bends up his knees at an angle, thus forming a kind of receptacle into which the eggs are laid. These eggs are yellow and are threaded together by sticky, elastic threads. Two to four layers of about ten eggs are laid. At the moment that the eggs are laid, the male shifts his hold on the female's waist to an embrace nearer to her head, and a little later stretches out his body in the act of fecundating the eggs. Again after a few minutes' interval, he attaches the strings of eggs to his own legs, passing his feet through

the egg-cocoon, and then holding the gelatinous strings against his abdomen, so that the egg-mass bulges out round the posterior end of his body, he retires to a safe retreat, where he hides during the daytime. At night he comes out to feed, and on these nightly walks the eggs are dampened by the dew. After three weeks he takes to the water, still carrying the eggs with him. By this time the tadpoles have hatched; they bite their way through the envelope of jelly which has held them together. Not till the last of the tadpoles are free of the egg-strings does the father toad disentangle himself of what remains. The tadpoles continue their life in the water in a way similar to other toads.

This curious behaviour is rivalled and perhaps surpassed by a Brazilian tree frog (*Hyla goeldii*). In this case the female takes charge of the eggs. Folds of the skin of her back form a dish-like receptacle, in which the eggs are placed. Presumably it is the male that helps her get them into this position. The eggs are comparatively few, twenty to thirty, and are well provided with yolk. They remain for the whole of their development on the back of the female, and from them emerge not tadpoles but little frogs, which still, however, have long tails. Instead of a large number of spawn being produced and being carelessly scattered, as with the common English frog, this animals lays but a few eggs, richly provided with food-material for the development of the young, and takes care of them by carrying them about on her back. Advantages over the more primitive, extravagant method are gained by the mother frog being able to seek out conditions suitable for herself and her charge.

A further development of the safe hatching-ground offered by the parental back is provided by a toad from tropical Brazil (*Pipa americans*). This toad, unlike the tree frog, lives most of its time in the water, yet it has adopted the same method of protection for its young; the skin of the back, in this case, instead of forming a mere flat dish to support the eggs, grows round them and over them, completely enclosing each egg in a separate cell. In these cells, each covered by a kind of lid, the young develop and emerge as tiny toads. This animal has a specially developed bladder-like pouch which projects, while the eggs are being laid, from the cloaca, and directs them backwards on to the female's back.

Other tree frogs of the genus *Nototrema*, also from South America, present variations of this same method of carrying the eggs on the

back. In this genus a single pouch is formed by folds of the skin of the back growing together and leaving but a small exit through which the young, in this case tadpoles, can escape. And yet another variation of this highly specialised method of carrying the young in a pouch is provided by a small frog from Chili (*Rhinodermata darwini*). The young are carried in an enlarged vocal sac, which when fully developed covers the whole ventral surface of the body. It is the males in this case which carry the young, but how the young get into this sac has not yet been discovered. Yet other variations are offered by the female frogs (*Hylambates breviceps*), which carry their young in their mouths during their period of development.

The comparative study of the frogs and toads in their methods of reproduction offers a great number of variations. A more detailed and tabulated account can be found in J. T. Cunningham's work on Amphibia, but sufficient has been said, in the above short descriptions and life histories, to show what different modes and expressions can be adopted by the purposive impulse of life to attain the same ends—and these within one group of closely allied animals.

INFANT VOYAGERS

For a long while it was unknown to science where the eel spawned. Professor J. Schmidt, a Danish naturalist, in the course of several cruises, and with much patient and careful investigation, has found that the spawning place is near the Bermudas and north of the Sargasso Sea. Actually where the eggs are laid still remains unknown, but it is presumed in deep waters. The young fish, newly hatched from the eggs, are found in millions in this region, and in the regions westward, whither they are drifted by the movements of the currents. They measure at first but a few millimetres in length and a fraction of a millimetre in breadth, and possess a minute, globular head. These tiny fry are called *leptocephalus*, and were thought, for some time, to constitute a species of their own, and were not recognised as being the young larval form of the eel. Their growth is slow, and those members of this vast host whose future destiny calls to them from European rivers, drift with the Gulf Stream. Three months after they are hatched, they are twenty-five millimetres long, still almost microscopic, and three months later are between thirty and forty millimetres. They grow regularly without changing their leaf-like form.

For three summers these little creatures live in the sea, drifting

their way, two thousand miles and more across the ocean, their vast numbers being preyed upon by all manner of creatures, as they make their long landward journey. At the end of three summers, when they at last reach the shores of England and France, they are only sixty to ninety millimetres long, extraordinarily small for their age. During this first period in their lives they have remained exceedingly passive, feeding on substances dissolved in the sea water, and by their tiny movements merely succeeding in keeping themselves suspended.

Though they have been born of their mother eels as eggs, as leptocephali they are in the ocean waters invisible and transparent and inert; in the ocean they seem as passive as other creatures are within the substance of their mothers, and are carried by this, their second mother, the ocean, whither she will. The slow, sure currents carry them to the land.

At the end of three years, and while yet suspended in sea water, the leptocephali undergo a change of form; they become smaller, less leaf-shaped and more pipe-shaped, more like adult eels. They are now elvers, and no longer passive organisms carried along by the currents, but active little fishes. They are still transparent, and will so remain until they enter the rivers.

The question presents itself: what conditions produce this metamorphosis from leptocephalus to elver? Possibly the different type of water which they now encounter in the neighbourhood of the land. It is almost certainly more oxygenated and less saline than water further out to sea. Whatever conditions they may be that produce the change, the young elvers are undoubtedly attracted towards the fresh river waters. They enter the estuaries, and a short while later, lose their transparency and become both pigmented and opaque.

The numbers of elvers which approach the shores of Europe every year are enormously large. There are thousands of millions. Not even a dense swarm of locusts will outnumber this vast migration which comes up from the sea towards the land. Huge quantities are caught in fine-meshed nets and sent in train-loads to cities to be eaten. Tons of them are pickled and preserved to tickle the taste of the gourmet. They do not only push their way up the rivers and watercourses, but sometimes fling themselves upon the land, crawling over the wet stones of the beaches, and through wet grass in search of waterways which will lead them inland. On Romney Marsh I have seen thousands of these little creatures, which had climbed

over the sea-wall near Dymchurch, and which were wriggling their way through the grasses. The dykes both above and below the dams were full of them.

And so they work their way upstream, driven by a tremendous and all-compelling urge towards a quite unknown and altogether different form of existence. Though they are so small and so numerous, they are old in years and experience. Each of them has travelled since the day of its birth, more than two thousand miles, and yet not one of them knows where it is going. As a corporate whole, as though driven by one will, they wriggle their way inland, sometimes in the rivers' mouths piling themselves up into stiff, jelly-fleshed waves of advancing life, myriads of individuals united in a oneness of purpose and desire.

Of those which escape the nets of the fishermen, and survive from the attacks of all the animals and birds which follow this host of young travellers to the shore, a fairly large number make their way up the rivers. These grow larger and stronger as they go, they seek the dark underbanks and travel mostly by night, avoiding the light. Two years after metamorphosis and five years after it was hatched, the young eel is about eight inches long, and its first scales are beginning to form in its skin. In another two or three more years, the males will become pubescent; the females, which develop more slowly, will take another year or so. These latter are then thirty to forty inches long, being about twice the size of the males.

There is an interesting point about the distribution of male and female eels in their freshwater resting-places. In certain ponds or streams the larger females seem always to predominate in numbers, and in other localities the males will always be the more numerous. The distribution of the sexes seems, in fact, to be determined by the localities. What is the cause of this distribution, and what is its result? The same migrations are urged upwards towards all these different localities, how is it that some localities are populated by males and some by females? Is it that the eels sort themselves out, the females going to one place and the males to another, or is it that the influence of the environment is able to determine the sex? If this latter supposition has anything in it, then we must assume that the elvers, as they ascend the streams, bear the potential of both sexes within them, and that male- or female-ness develops according to the influence of the environment. There are some naturalists who believe this

to be the case, others hold, however, that the sex is already determined in the egg, and that the young eels sort themselves out, as our own children are sorted out when sent to boys' or girls' schools. The question remains open to further investigation.

During their stay in the rivers and ponds, eels are known to hibernate during the winter. They dislike cold, and they dislike light. They seek for warm, dark places, and there curl up and remain quiescent until the return of spring. When warm weather returns they become active once more. They have great vitality and as everybody knows they are extremely difficult to kill. Even when their bodies are cut up into small pieces, each part will remain wriggling. This vitality also enables them to resist and to survive in an uncongenial environment. When other fish are poisoned by polluted water, eels can live, and when ponds dry up, and other fish perish as the water disappears, the eels can burrow deep into what mud remains and provided there is but a modicum of dampness they will survive.

After the eels have achieved the necessary growth, and the period of pubescence has arrived, they will, each and all, as soon as that critical period has come to them, be visited by that compulsive feeling which tells them that they must make their way out of their ponds, back to the rivers, and down the rivers, down towards the sea. It is during the autumn that this feeling comes to those who are fitted to take on their long wedding journey. These are the strongest and the oldest; the others not so strong or not so old are unaffected by this impulse.

When they reach the sea, they do not delay in the coastal waters, but make straight for the depths. In vast numbers they go, seeking the darkness and avoiding the light. As soon as they are fairly at sea, they disappear completely. They seem to lose themselves, leaving no trace behind. Occasionally an odd individual is caught in shallow water, but the vast majority disappears. We can trace their course no further. We only know that when sexually maturing, they have gone down to the sea, and we know that the small leptocephali, their larval form, come from far across the sea, turn into elvers, which make their way up into the rivers, and grow into eels. Since the leptocephali are found at their smallest and youngest in the neighbourhood of the Sargasso Sea, we must conclude that the eggs are laid in that region of the ocean, and that the eels travel all that way back, swimming against the current of the Gulf Stream, being led in that direc-

tion by the attraction of the warmer waters, till they come to the predestined spawning-ground. Why they have been led so far, and to this particular place, we cannot tell, nor can we even guess. All we can say is: this is the pattern of their fate, the pattern they must follow.

What happens to the parent eels after they have mated and spawned we do not know. They are never seen again, they do not come back, either to the rivers or the shallow waters. The conger eels which are so frequently caught in the sea are not the same species of eel as are those which are found in our rivers. These true river-frequenting eels, perhaps, like the salmon, die in large numbers when they mate, or perhaps live for many years in the deep sea. Only the growing period of this species is spent in fresh waters. The birth and the death, and perhaps the full maturity and ripe old age are accomplished in the sea. These creatures present the reverse habit to that of the salmon. They are deep-sea-water fish which breed and spend their early youth in the sea; they wander across vast territories of the ocean to reach the land. They then spend their growing period in the rivers and ponds. The salmon can be considered a freshwater fish, that breeds in the mountain streams and spends the first period of its youth in freshwater. It then goes down to the sea, and in the sea remains during the period of its growth, and when pubescent, it returns to the rivers. Each species under its own peculiar compulsion accomplishes a destiny which must leave the beholder wondering and astonished at these strange inter-relations between living creatures and their environment.

It should be mentioned before leaving this subject of the eel and his voyagings, that some few individuals fail to make the return journey to the sea. These—if confined in tanks or ponds from which it is too difficult to get out, and so be able to travel in response to the impulse of their pubescence—these must of necessity remain behind. They do not languish or die, but if the critical period for migration is missed and they remain where they are, their sexual organs become sterile. They grow large and sleek, become great gormandizers and live to a ripe old age. Such are the giant freshwater eels which are sometimes caught, and about which paragraphs are written to the newspapers by the proud fishermen who have hooked them.

LOVE AND HUNGER

The salmon, in their migrations from the deep sea into the rivers, come in groups and parties according to age and size. In autumn and winter come the largest, oldest fish. These are often a yard or more in length and weigh from thirty-five to forty pounds. As their scales indicate, they are five to six years old. In the early spring groups of smaller fish follow, taking the same course up the rivers towards the source; these are mostly four-year-olds, and their weight varies between eleven and twenty-two pounds, and their length from twenty to thirty inches. In summer only a few fish come in small groups, these weigh six to seven pounds, and are almost all males. All these fish, whatever their size or weight, are bound for the same destination, and are moved by the same impulse to leave the deep sea where they have been feeding, and to work their way up through the fresh, strange waters of the rivers, up to the highest source, where the springs run cold and clear from the earth or from the dissolving snows of the mountains.

This journey is a journey towards a marriage rendezvous, and it is a remarkable fact that the salmon while engaged upon it eat very little food. It is true that they will snap at flies, but it seems probable that they get very little nourishment from such light trifles, for their stomachs when examined are found to be empty. The impulse which

drives them upwards towards the heights of the mountains is one which is so strong as to make them face, what would seem to an unprejudiced observer to be, insuperable difficulties. It is well known how salmon will jump again and again at falls and cascades, and where they are at first unable to make their way, they will wait till flood-water makes possible their ascent. Once the journey from the sea to the mountains is started, they have to fight their way upwards against the very water in which they live; they cannot slacken their efforts, for if they do, they will be carried back from whence they came.

In this ascent of the rivers, there is a definite course which is followed year after year by each successive migration. At the dividing of waters, where tributaries join the main streams, the fish choose one course and leave the other. This choice, which at first sight would seem to be mysteriously their own, is determined by their reaction to the water in which they swim; they follow that which is most rich in oxygen. Their need, on this long wedding journey, is for a rapid and intense metabolism. Their sexual glands, which were small and undeveloped when they left the sea, have need to grow so large as to constitute a quarter to a fifth of the total weight of the females, and a tenth of the weight of the males. This change demands a rapid life process, a generous oxygenation of the tissues. The salmon, seeking the most foaming eddies, the fiercest cascades, gets ever nearer to the river's source, where the proportion of oxygen in the water increases continually, thus stimulating the fish to greater activity and vitality.

So far as the actual mechanism of this long journey is concerned, we can say that it is determined by reaction of the fish to the kind of water which surrounds it; but what is it which produces this sudden turning aside, or *tropism* as it is called, from the life in the deep sea, where the fish feeds greedily, to this other quite different sort of life in the river, where different conditions control and stimulate a different kind of metabolism? This question is not easy to answer in its deeper implications. We can say, superficially, that its sexual needs determine this change, but even if we accept so facile a statement, the fact is yet sufficient to stir our wonder that a deep-sea fish should be driven out of the saline and light-less waters where it is accustomed to find its food, into the exposed and fasting conditions of a fresh-water river. Why, indeed, should it behave in this way? But first to return to the subsequent events in the life history.

The salmon, whether they are heavy four-year-olds or the light six-pounders of the summer migration, reach their destination by the late autumn of the following year. Here, amongst the shallow waters of the snowy mountain tarns, they prepare for the marriage ceremony.

They can go no higher, since the water is scarcely sufficient to cover them. For weeks and months they have been battling their way upstream, and now they do not rest, but dart about in a state of increasing agitation. They have not all arrived at the same time. The big, heavy salmon which started in the autumn have reached the spawning places early in the following spring; these wait till the winter, and spend as much as twelve or fourteen months in fresh water. Those which started later spend less time in the rivers; all are at the rendezvous for the breeding season which begins usually in December and January. In these shallow, highly aerated waters, which are constantly whipped into eddies and cascades, the life processes of the salmon are yet more accelerated. The colours are changed by the products of excretion beneath the skin, and the salmon appear indeed to be suffering from the intensity of their crisis; they are emaciated, with distended abdomens, for the reproductive organs have grown large at the expense of the rest of the body.

Often the males begin to prepare the spawning places, making longitudinal hollows in the bed of the stream. The females finish the work which the males begin; they press and rub against the stones, squeezing out an enormous quantity of eggs. At this period the female is accompanied by one or more males, which, following after her, press down with similar contractions, shedding their milt on the ejected spawn. The females go from spawning place to spawning place, leaving intervals of time between the laying of the eggs, for the eggs do not all ripen at the same time. The males follow them eagerly, and during this spawning period nothing seems to matter to them but the satisfaction of their desires; they are lost to all sense of fear, being completely under the compulsion of that urge which has brought them so far from the dark depths of the sea.

When the spawning is over, the salmon are near the end of their strength; they are emptied of those sexual products which all their best powers have gone to produce. Long, emaciated and muddy-looking, they are but shades of what they were; many, though still living, are on the point of death. All their excited vitality has burnt

itself away, they let themselves go with the water, having hardly the strength to swim. Large numbers do not survive this period of profound depression. Those which survive snap ravenously at anything eatable, for they are starving; and slowly they are carried down by the current to the sea from whence they came. In the deeps of the sea they recuperate and become strong again, and when they have recovered their beauty and their strength, they will again, at the appropriate season, rise up out of their deeps to the shallow water and seek the river mouths, and the oxygenated water, which in the end stimulates them to that flurry of sexual activity which is the death of so many.

The eggs, which remain in thousands on the beds of the mountain streams, develop slowly into the small fry, which at length, in midwinter, emerge from them. These, as yet but partially formed, drag a vesicle of yolk behind them. This vesicle only gradually becomes smaller, and is withdrawn within them; the fins harden and become pigmented; the fishlet begins to swim and gathers strength to face the current. By the spring it is an agile little creature, hardly larger than when hatched, but better formed, and recognisable as a young salmon. For two summers the young fish remain in the mountain streams where they were born. They are now from six to seven inches long, active, lively little fish, with bronzed backs speckled with black, their pearly sides adorned by light or dark blue patches. They are now called smolts, and at this stage begin their journey downstream towards the sea. They travel slowly and in stages, letting the water guide them in an idle, easy descent. At the river's mouth they meet the salt water for the first time, and here they wait for a while to get used to this change of condition before committing themselves to the sea. Then as though inspired with confidence, they strike boldly out into that new world of waters, swim into deeper depths, over the Continental Shelf, down into the dark, cold regions of the ocean, where no light penetrates.

Since salmon are very seldom caught after they have left the rivers, it is a matter of inference what happens to them during their long stay in the sea. But as Louis Roule in his book on *Fishes, their Journeys and Migrations*, points out, our inferences are founded on facts which can bring us near to certainty. No salmon are found in the rivers which drain into the Mediterranean, therefore we may assume that the full-grown fish come from the Atlantic Ocean, and that the

young fish go down into the Atlantic Ocean. Only very occasionally is a young salmon caught on the Continental Shelf, namely in the shallower waters near the land. It is probable that they go down to the middle depths, to three to five thousand feet deep. These middle depths, although devoid of vegetable life, since no light penetrates there, are very rich in animal life. Here there are hosts and swarms of crustaceans, and it is believed that the salmon feed particularly on prawns and shrimps. The carapaces of these shrimps are of a reddish pink, and it is this pigmentation of the shrimps which gives to the flesh of the salmon its characteristic colour. That delicious pink flesh that we eat so light-heartedly and take so much for granted, has been built up by the salmon in the dark depths of the sea where no human eye has ever penetrated.

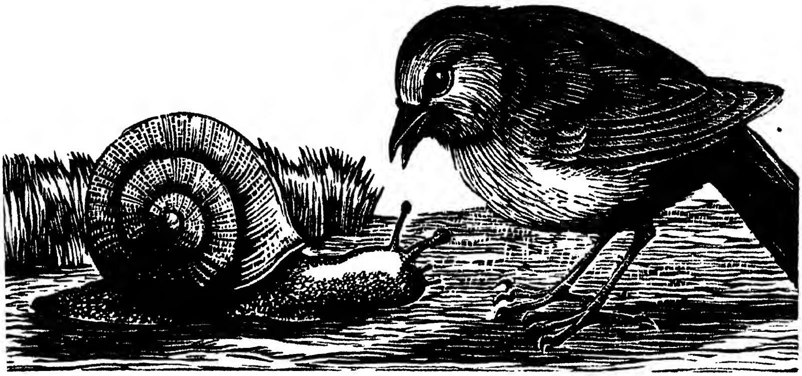
For three or four years the growing fish are altogether given over to the business of feeding and the process of growing. They grow rapidly, at a rate which is far faster (double, even triple or quadruple) than that of other fish. They are great eaters, consuming and assimilating continuously. How in the darkness do they find their food? In these middle depths of ocean, life is so profuse that food surrounds them whichever way they turn. Swarms of red shrimps are rising up or settling down all the time; the salmon have but to snap their jaws to receive such easy victims, their gustatory and auditory sensations being sufficient guide.

So in the darkness they feed and grow, until they are moved by another kind of impulse. Perhaps they are wearied of that perpetual feeding; their hunger is satisfied, and another life moves within them, a turning aside from one expression to another. Their love for the rich, food-filled darkness is now replaced by a completely different desire.

Such a change as this is, of course, not peculiar to the salmon alone, though in the salmon it is particularly well marked. All migratory creatures have like experiences. In response to an impulse which comes from we know not where, perhaps from the unanalysed centre of their inner being, perhaps from the unlimited immensity of the surrounding cosmos, perhaps from both, they change their manner of life, and start on journeys whose destinations are quite unknown. For the salmon the destination must be unknown. The fish can but be aware only of the water which surrounds its body. The transition from saline to fresh must be a mystery to it; it has no knowledge of

the river banks on either side; it follows the lure of the oxygenated water; that is all it knows, its need and its satisfaction. It moves under compulsion, and the end of its long journey is the spending of its vitality in the excited and extravagant spasms of reproductive ecstasy, an ecstasy most frequently followed by such exhaustion as to cause death. And one is tempted to question whether death is not the natural sequence of such devotion, such obedience.

Changes of heart, religious conversions, are for men as unexplained, as irrational as are these seasonal tropisms in migratory animals. They also mark the beginnings of journeys whose destinations are unknown.



THE MILLIONTH CHANCE

Creatures which live for a large portion of their existence inside the bodies of other animals find many difficulties in providing for the safe housing of their offspring. Although the parasite is comparatively secure when surrounded by the warm and living body of its host, there are numerous hazards to be met before the next generation can find itself in an equally advantageous position. How is it possible for an animal living within the body of another animal to get its young into the body of another similar host? To get from one enclosed retreat into another must be at the best a chancy business when the individual concerned is only adapted to a highly specialised and protected form of life, and would inevitably perish if it ventured in person amidst the inclemencies of the surrounding universe. The answer to this problem, which in all probability emerged at the same time as the conditions which evoked it, is found in most creatures by the production of an enormous number of eggs. These eggs are cast out into the world, the greater portion of them destined to destruction, and the few that survive surviving by the merest chance, or often by a combination of chances. These few, these ones out of millions, are sufficient to carry on the species.

The parasitic animal, when it is completely enclosed within the

body of the host, has very little to do in regard to the normal processes of living. It has no need for sight, since it lives entirely in the dark; no need for hearing, little or no need for taste, since it is often surrounded by the food which it absorbs through every portion of its skin. It has little need for touch or for movement, and many internal parasites are altogether inert. Its digestive organs can afford to be of the most primitive nature; its sense organs atrophied. The sexual organs are thus able to occupy the whole attention (if I may use such a term) of the individual. They grow large, often complicated, and self-fertilising, so that one isolated individual does not need the co-operation of another for the production of fertile eggs. In some cases the sexual organs occupy practically the whole of the body space of the parasite. They produce a vast quantity of eggs, of which only a very few are able to survive the dangers and difficulties which must inevitably intervene between their leaving one host and arriving safely within another. Strange and circuitous paths must be followed, and the pattern of each specific destiny would seem to have been determined by the most unpredictable chances.

In such animals as these, although they vary in many ways and derive from different orders, we find the following main characteristics. The sense organs, ambulatory organs and digestive organs are all atrophied or poorly developed, and the sexual organs are enormously developed; the life histories are complicated and often carry the parasite through the bodies of several hosts before bringing them back into the body of that host from which the eggs in the first place were liberated.

An extreme example of the growth of the sexual organs of an internal parasite is offered by *Spherularia*, a very small nematode worm. This worm lives in a free condition amongst the moss and earth composing the nests of humble-bees. After the worms are mated and fertilised, they attach themselves to the humble-bees and work their way into the body-cavities of the insects. Inside the bees they wander about in the body-cavity, where they obtain nourishment by absorbing fluid food through their skins. As soon as the worm is safely inside the bee, and it has taken up a parasitic form of life, the uterus of the worm begins to grow; it becomes so large that it pushes itself outside the body of the worm, and continues to grow enormously. It becomes vastly larger than the worm, which soon appears as a small appendage to the swollen uterus. Eventually the

body of the worm withers away and disappears, the uterus alone remaining in the body cavity of the bee. The uterus bursts, liberating a large number of eggs; these hatch into larvae, which penetrate the gut-wall of the bee and so pass out on to the soil and there become free-living, until such time as they can happen upon a bee's nest and pass again into another generation of bees.

Such a life history is comparatively simple, and is far surpassed in complexity by that of the liver fluke. The adult liver flukes which are short, flat, unsegmented worms are provided with suckers by which they hold their position in the bile ducts of sheep. They are the cause of liver disease, and besides being found in sheep occasionally occur in man. The adult flukes are hermaphrodite and produce a very large number of eggs, which pass out into the gut of the host, and from thence, in the droppings of the host, to the outer world. The eggs, if they happen to fall in a damp place, hatch into a small ciliated larva or embryo; this creature wriggles about on the wet grass, and if it is lucky, or if aided by a fall of rain, may find its way to a pond. It can swim in water; and, again if it is lucky, it may happen to encounter a water-snail. In contact with a water-snail, it has an impulse to bore into the soft flesh. It works its way through the snail till it reaches the blood stream, and ultimately the liver. Here it forms a cyst, which cyst has the power of giving rise, through a multiple budding-process, to a number of larval forms called rediae. Each redia has the power of producing more rediae, and so on for many generations within the snail. The rediae at length give birth to a different form of larvae, called cercariae. The cercariae are provided with long tails, they leave the snail and swim about for a short time in the water of the pond. They finally crawl up grass-blades, and when free of the water, they encyst. They then wait inactive, and the majority of them perish, since they are unable to proceed any further unless they happen to be eaten by a sheep. They must also have the good luck to be swallowed by the sheep without being crushed by the teeth. Inside the sheep, the cyst develops into a young fluke, and may, if it is again fortunate, be able to enter the bile duct, where it grows to be an adult fluke and capable of producing in its turn a large enough number of eggs to meet the many hazards of its fate.

This animal, as it has been seen, must encounter many favourable chances if one of its many eggs is to survive and grow to an adult. In the first place it must have the good fortune to be dropped in a moist

situation. It must then be able to find its way to a pond. It must then be able to find a water snail; no easy thing for so minute a creature in a comparatively enormous pond. Inside the snail it reproduces itself a thousand-fold. The proceeds of this reproduction escape again into the water as free-swimming creatures. They must now reverse their earlier journey and find the shore. Throughout these various activities, they appear to be led by some guiding principle which is reponsible for the ramifications of a destiny, so well synchronising with their needs. Having at last reached the grass blades, the cercariae encyst, and here again they are either the victims or the favourites of chance. Should they be eaten by a sheep (and how many chances are there that they should not be?) they survive to carry on their species—that enigmatical expression of life which preys upon two such dissimilar creatures as a sheep and a water snail.

Another allied worm which shows several resemblances to the liver fluke in life history is the lung fluke. This worm enters the body of a man, being swallowed in uncooked crab's flesh. The flukes develop in the lungs, causing illness. The eggs are coughed up, and spat out. If they happen to fall in water, they hatch into ciliated larvae. These swim about until they meet a snail, which they enter. In the snail they produce rediae, which produce other rediae, and finally cercariae. The cercariae work their way out of the snail, and should they meet a crab, penetrate into its flesh, where they encyst. They can develop no further unless the crab is caught and eaten by man in an uncooked condition. This animal has three separate and different kinds of hosts, and must make three hazardous passages from one to the other before the life-cycle can be completed.

Leucochloridium is another trematode worm, inhabiting the intestines of small birds such as hedge-sparrows, robins and warblers. Its eggs are laid in the intestine and pass out with the droppings. For their further development they must be eaten by a snail. The larval form develops, in the snail, into a cyst of a peculiar kind which sends growths up into the snail's tentacles. These growths are brightly coloured and possess a rhythmical pulsation. These bright-coloured objects with their noticeable movement are liable to attract the notice of small birds, which latter, being often of an inquisitive nature, are liable to peck at and eat them. These birds it should be noted are too small to eat the whole snail. As soon as the coloured cysts are within the guts of the birds, they develop into adult trematodes. It is prob-

able that only young birds are infected in this way, the adult birds being able to digest and so kill the cysts. How interesting it is to speculate on the destiny of the snail, which is infected by the sporocyst of the trematode and whose highly coloured and unnaturally bright tentacles are snapped off by the unwary birds. Must we not inevitably see in this relationship a parallel to the more subtle and hidden associations which occur in human beings, and which are only recently being revealed by the researches of the psycho-analysts? Were there a modern Aesop, how pertinent a fable might he not write!

The tapeworm, which is so prized by those races of mankind which measure their manhood by the amount of food which they are able to ingest, is another example of an animal, degenerate in everything but its sexual development, and whose destiny, governed by hazardous chance, completes a cycle within the bodies of various hosts. The tapeworms are to be found in men, pigs, dogs and rats. In men who eat mightily they are by no means an unwelcome parasite, for their demands on the nutrient juices keep their hosts always hungry. Indeed I have known a doctor who boasted that he made a habit of giving to his more gluttonous patients the scoleces of tapeworms secreted in bread pills. The resulting infection would reduce the weight of the patient, and at the same time allow him to indulge in the pleasures of the table with greater impunity. I have heard it said that no Arab is considered healthy unless infected by one of these obliging parasites.

A tapeworm may be considered as a string of degenerate individuals, each consisting of a sac-like body with but the most rudimentary nervous system, and devoid of limbs or digestive tract. Nourishment is taken in from the surrounding medium through the skin. Each individual contains an elaborate hermaphrodite sexual apparatus, and each is budded off in turn from the head or scolex, which, with its hooks, is firmly fastened to the wall of the host's intestine. As the individual segments grow further and further from the budding scolex, they grow in size and maturity, until, when they are full grown and fully ripe, they break off and pass out with the faeces. They have the power of moving themselves for short distances by the contraction of their muscles, turning themselves over and over, like so many animated portmanteaux. Should they be fortunate, they are dropped in damp grass. Ultimately they burst and let loose a vast number of eggs.

The ensuing life histories vary with the different species. In the Pork Measle Tapeworm the scolex develops in the intestine of a pig, the segments pass out on to the earth and there burst. The embryos which emerge from the eggs are, if they are lucky, swallowed by another pig. They then penetrate the gut and enter the bloodstream. From thence they pass into the muscles, where they encyst. There they must remain until the host is either eaten by another pig or by man in an uncooked or semi-cooked condition. As soon as the cyst finds itself in the alimentary tract, a scolex is developed, and this will bud off segments forming a typical tapeworm.

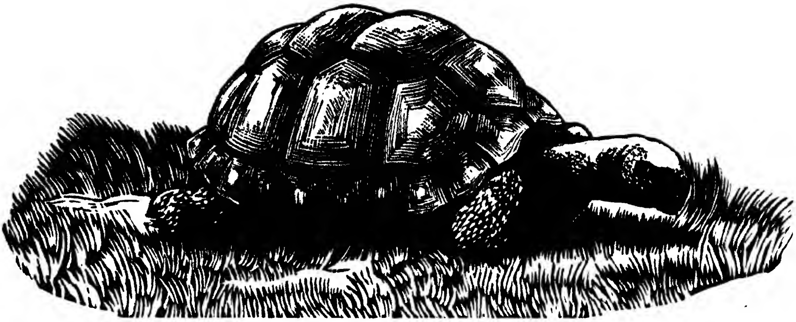
Another comparable life cycle is provided by the broad tapeworm. This is adult in man. The eggs escape from the segments in the faeces. These can only develop if they are dropped near water. Swimming embryos emerge, and should rain and the slope of the ground favour them, they make their way to a pond. Here, if they are to develop further they must be swallowed by a cyclops, and again, if they are not to die with the cyclops, the cyclops must be in its turn swallowed by a fish. The fish must ultimately be caught and eaten in an uncooked condition by man for the tapeworm cycle to be completed. In this case the chances against the survival of any individual egg and the proceeds of that egg seem fairly heavy. Only the enormous number of eggs produced can compensate for these adverse chances.

In contrast to creatures such as the tapeworms which inhabit various hosts, there are other worms, and these of a less degenerate nature, which live all their cycle in one animal, and explore, during their different stages of development various parts of the body of that animal. *Ascaris lumbricoides* is a round, fairly active worm, which, in the adult form, inhabits the intestines of a pig. The eggs of the worm pass out in the droppings, they are picked up from the ground by another pig and swallowed. They hatch in the small intestine. One might suppose that this short cycle was now complete. The young are back in the intestine of another infected individual. All that would seem necessary is that they should develop and produce eggs in their turn. The cycle is not, however, so simple. The young worms burrow through the walls of the intestine, enter the blood-system and travel to the liver, thence to the heart and thence to the lungs. Here they cause irritation and bleeding. They are coughed up into the windpipe and thence to the mouth. They are again swal-

lowed, and when, for the second time, they enter the intestine, they develop into the adult form, and produce eggs.

Trichinella spiralis is another non-segmented round worm whose adult form inhabits the small intestines of men or rats. The females do not lay eggs, but give birth to larval forms, having first bored through into the lymphatic spaces adjacent to the intestinal wall. The larvae pass from thence into the blood-system, and finally into the muscle fibres, where they encyst. They can develop no further unless the host that they are inhabiting is eaten by another animal. They are then liberated by the juices of digestion. They pass into the intestine, where they cause great irritation and disturbance. They are now adult, and the cycle is complete. Such a creature as this is not common in civilised countries in normal times, as the conditions favouring its propagation are not present. In times of war or plague when human bodies may lie about unburied, and may be eaten by rats or pigs, then the necessary conditions are supplied. The cycle may also be completed in the rat and the pig, the adult form of the worm occurring first in the rat, and the rat being subsequently eaten by the pig.

The above life histories are but a few of the many and intricate patterns formed by internal parasitic animals, animals which are all characterised by a high sexual potency, competent to produce a sufficient number of eggs to compensate for the risks and dangers which must be met in the passage from one host to another. What is most remarkable about them is the seemingly directive impulse which brings the straying larval forms back after many adventures to the place from which they started.



TORTOISES AND TURTLES

The ancestors of the tortoises and the turtles are unknown. If we are to suppose with the evolutionists that they are descended from ancestral forms, then those ancestral forms have failed to make their appearance amongst fossil remains.

Tortoises are distinguished by the hard and rigid shell which encompasses them. The upper portion of this is called the carapace, this is formed of bony plates which originate in the skin; the upper plates of this carapace lie directly upon the spines of the backbone and on the ribs, to which in the course of their development they become welded. There is consequently no space in which the limb girdles, should they retain their normal position, would be able to function. The limb girdles lie in all other reptiles, and in all other vertebrates, between the ribs and the outer skin. In the tortoises and and in most of the turtles, the dermal plates and the ribs and the backbone are fused together and so the limb girdles are conveniently placed inside the ribs.

If we assume that the tortoises have been evolved from some ancestral form, from which other, more normal reptiles have also derived, then that ancestral form must have either had its limb girdles

outside its ribs, or inside. In either case a great and startling change must have taken place when the limb girdles were transferred either from the inside to the outside or from the outside to the inside. Such a change is impossible by any series of slow continuous variations. If such a change occurred as the result of a mutation, then such a mutation, which involves the removing of a girdle of important bones from the outside of the ribs to the inside of the ribs, and the consequent necessary changes in the muscles and all the interior organs of the body, may well be called a separate act of creation.

In the tortoises we find a large group of animals reptilian in their characteristics, and yet separated from other reptiles by so fundamental a difference as this placing of the limb girdles. It must either be assumed that they were created very much in their present form, and have since like all other creatures suffered various changes through devolution from their archetype, or that they are evolved from some extinct and altogether unknown reptilian forms which were essentially different, in such an important respect as the placing of the limb girdles, from the ancestors of all the other reptiles. In this latter assumption we are still faced, if we trace our two lines of descent far enough back, with parallel development, which parallels cannot meet unless we postulate its extraordinary *mutation* which transfers the limb girdles from one side of the ribs to the other. This, as I have already said, might as well be called an act of creation as a mutation, so great are the corresponding changes implied.

The tortoises in this way present the evolutionists with a knotty problem, and it would almost seem that in contemplating the tortoises, we are forced to believe that at a certain period in the earth's history, they were precipitated. They are exceptional creatures, enclosed in a plated box, and, as a result of this enclosure, the majority of the muscles of the trunk are completely lost in that part which touches the shell. Traces, however, of these muscles exist in young specimens. Tortoises are creatures completely adapted to finding protection within their shell, they live enclosed within it, with only very limited capacity for movement. They cannot even bend their bodies, only can they thrust out and withdraw their heads, and walk slowly on their toes.

As the carapace is so strangely modified to unite the skin and the ribs, so the under-plate or plastron is formed by a union of the dermal plates with the collar bones and with presumably the abdominal

ribs. The marginal plates of the carapace which join with the plastron are formed only from the skin and make no corresponding fusion with any part of the internal skeleton. In some cases, as in ordinary land tortoises, the carapace is joined to the plastron by a bony bridge, so that the whole structure forms a firmly built box into which the head, limbs and tail can all be withdrawn; the horny beak and the horny shields on the legs effectively guarding the apertures.

The marine turtles though built on the same general plan are not so completely protected as the land tortoises; the upper and lower halves of the shell are disconnected, and the head and neck cannot be withdrawn under the margins of the carapace. The four limbs are modified into flippers, the digits of which are lengthened, but without increase in number or marked alteration of form. The body is flattened, as compared with the tortoises, and heart-shaped. These modifications allow of an easier passage through water. It is probable that the marine turtles are derived from the land tortoises, and in most cases the dermal plates are welded to the ribs and backbone as in the tortoises. The leathery turtle or luth is an exception. The upper and lower portions of the shell of the luth form one unbroken case all round the body. This case is composed of many hundreds of little bony plates, closely fitting into each other like a mosaic. These plates are deeply embedded in the skin, covered by it both externally and internally. They are nowhere in contact with the skeleton, except at the nape of the neck.

Different opinions are held as to the position of the luth in relation to the other marine turtles. Some biologists regard it as a degenerate modification of the normal type, others regard the luth as an independent type of different origin. This is indeed a most puzzling creature. Its form and structure express the same idea of protection and adaptation; but different means and different shape and size of the protective plates, and a quite different arrangement of them, have effected the same ends. If we are to make any inference from the contemplation of such an expression of life, then we must believe that certain ideas are materialising in animal forms, and that the means by which these ideas are manifested are not always the same. Nature is expressing invisible values through visible forms.

Turtles and to a lesser degree tortoises are possessed of an extraordinary vitality. They are extremely difficult to kill. On the first occasion that I had camped on a tropical island (we had arrived in a

sailing boat at night, and had set up our beds on the beach) one of our party found, in the early hours of the following morning, a female turtle that had come to lay her eggs in the sand. He turned the turtle on its back, and came to tell us of his find. Since we thought we might be hard up for food on that island, we lightheartedly decided to kill it, and set out, thinking the task might be accomplished by breakfast-time. There were three of us and we had knives and a good rope. By midday we had managed to cut its throat, and remove most of its internal organs. The heart continued to beat in a small pool of sea water in which we placed it, pumping the water in and out as though it were its accustomed blood; this it continued to do for several hours. The rest of the turtle, minus its inside, continued to beat its flippers to and fro till they were cut off. Blood-stained and exhausted we separated the upper and lower shell (no light task), and cut some of the meat up into steaks. These steaks of meat, which we placed on ledges of rock to keep them out of the sand, wriggled and crawled off the rocks by means of their contracting and expanding movements. Never, never, we decided, would we ever attempt to kill a turtle again!

Besides having a tenacious vitality in all their parts, tortoises and turtles are also extraordinarily long lived. 'In the year 1766 five tortoises belonging to the species *Testudo sumerrei* were taken from their island in the Seychelles and were carried to Mauritius, where two were living a few years ago. The most celebrated of the pair is one at the Artillery Barracks, Port Louis, of which the shell measures forty inches in length in a straight line. Since the dimensions of the shell are reported to have been practically as large so long ago as the year 1810, it is certain that this tortoise must have been very old at the time of its arrival in Port Louis; and something over a century would probably be a moderate estimate of its age at that date. Accordingly, it would seem that the reptile cannot be much less than 250 years, and may be much more.' Other cases of the extreme age of tortoises and turtles are not hard to collect.

Among the more unexpected qualities of tortoises is the power that some species have of making a kind of whistling or piping noise. The peculiarity of this noise is that it is produced by rubbing together two patches of horny tubercles on the hind legs. The note that this friction gives is clear and audible at a considerable distance. These tubercles are formed only on the male, and the notes are only produced during

the breeding season. These same tortoises which can produce this sound are provided with a very strong-smelling secretion which can be exuded at will, and which has given to them their popular name of 'stink-pot terrapin'. This fetid secretion is no doubt a means of defence. Tamed specimens of this tortoise do not produce this bad smell when they have become accustomed to being handled.

In his account of the Galapagos Archipelago, Darwin tells of the giant tortoises which inhabit these islands. The Galapagos Islands are volcanic in origin, and, measured in geological time, not of very long duration. They are between five and six hundred miles off South America, and they have a flora and fauna of their own, which includes many South American species. There is only one indigenous mammal, a small mouse; but in the absence of mammals there is a large population of tortoises. In the same way that New Zealand, in the absence of mammals, is populated by flightless birds, so are the Galapagos Islands populated by tortoises. They are large and black, and weigh as much as two hundred pounds and more. How they got to the islands no one knows. When first discovered, they were exceedingly numerous. They live chiefly upon cacti and lichens, and since the islands are very short of water, often have to walk a long way for a drink.

Darwin describes how that he found these large tortoises to be almost completely deaf. 'I was always amused when overtaking one of these great monsters,' he writes, 'to see how suddenly, the instant I passed, it would draw in its head and legs, and uttering a deep hiss fall to the ground with a heavy sound as if struck dead. I frequently got on their backs, and then, given a few raps on the hinder part of their shells, they would rise up and walk away; but I found it very difficult to keep my balance.' This was a young Darwin of twenty-four, not the venerable figure with whose picture and statue we are all so familiar.

Herman Melville, the author of *Moby Dick*, also describes these large black tortoises, and found in them the same quality that I have found in turtles, namely an obstinate desire to go in a straight line. I have known a turtle push for three days at the same place in the side of a stone pen in which it was enclosed. At the end of the third day it pushed aside the boulder and escaped. Melville describes a tortoise from the Galapagos Islands, which had been brought on board a ship, pushing for a whole night at the base of the mast. He goes on

to describe how he has 'known them in their land journeyings ram themselves heroically against rocks, and long abide there, nudging, wriggling, wedging, in order to displace them and so hold on their inflexible path. Their crowning curse is their drudging impulse to straightforwardness in a belittered world.'

ANCIENTS OF THE EARTH

The Australian bush in the region of Southern Cross and some thirty miles south of the Perth and Kalgoorlie railway line is semi-desert country. The granite plains are covered with sparse scrub of mulga bushes. The red dusty earth is bare of herbs for the greater part of the year, and only after the short, occasional rains do there follow sprouting and blossoming periods, soon to be withered and dried up by the sun's heat. Besides the mulga, malle and cassurina bushes, there are occasional clumps of white gum, and here and there solitary salmon gums; and over the red dust are littered the remains of such occasional trees which have lived there in the past, and have fallen, to rot where they lie. These tree trunks soon become hollowed out by ants and other insects. The inside of their stems appears to be softer than the part immediately under the bark, and so, in the process of decay, there is a period when these fallen tree trunks form easily excavated tubes in which small animals can find shelter and safety.

Rabbits are the chief inhabitants of these tree trunks, but bandicoots, boody-rats, snakes and other creatures also use them. So also do the echidnas or bush porcupines. These very primitive mammals are interesting for various reasons, and while I was in Australia I collected some half-dozen, which I kept alive, and had hoped to bring back to England.

The method of capture was as follows. I borrowed a dog with a

'good nose' from one of the miners who was working at the Bullfinch, a mine which was destined to become world-famous a few weeks later for its rich veins of gold ore. With this dog, and armed with an axe and a large sack, I went hunting. The dog would smell at the logs, and if there were a rabbit or an echidna in the log, he would scratch at the place where the animal was. A piece of wood could be used to block up the open end of the log, and then, when it was split open, the animal could be captured or killed. There were more rabbits than echidnas; but by hard work I managed to collect six of the latter. These I kept alive and tethered out in the neighbourhood of my tent. At night-time they were noisy companions, grunting and sniffing and straining at their tethers and scratching at the earth, but I managed to keep them all safely so long as I was in the bush, and during this time I learnt something of their habits and their appearance.

During the day-time they would remain under the sacks which I left for them to shelter under from the sun. If the sacks were removed, they would press themselves close to the earth, and tuck their long noses under their bodies, as though hiding their eyes from the light. In the evenings, provided all was quiet, they would walk to the limit of their tethers, and would sometimes eat ants with their long extensile tongues.

These specimens which I kept in captivity for varying periods from a week to a month were always very shy, and not, like bandicoots, easily tamed. An observer must keep very quiet and at a distance to see them in action. Sometimes I would let them go free and follow them, and once had the good fortune to see one dig out an ant's nest and make a thorough good meal of the ants. When my echidnas imagined themselves to be free and unobserved they could go at a fair pace, holding their bodies well up from the ground and flattening their quills upon their backs. None of my specimens had young during the short time they were with me, for I was too late for the breeding season. It is in September that the mother echidna lays her egg. The egg is soft-shelled, and it is probably laid directly into the pouch. The young is hatched in the pouch, where it suckles like any other young mammalian. During the time it is in the pouch it appears very helpless and quite unprotected. Later, when it has grown its first few quills, it is deposited in a nest in some dry, safe place, where it remains till old enough to be weaned and able to look for ants for itself.

I was told by Australians who had been fortunate enough to capture these creatures when they were young, that they made quite tame pets, coming when they were called and following their owners about like dogs. My own echidnas remained wild and distrustful, and finally escaped in the hotel at Southern Cross. I was hoping to keep them with me till my return to England. For safety I had them in my bedroom, and since I was sorry to keep them constrained in sacks, I loosed them for the night, after having locked the door to make sure they should not escape. As soon as the light was out they began marching round the room; pressing themselves between the wall and any piece of furniture, shoving the furniture about, and threatening to upset a heavy wardrobe. However, I did not think they could come to any harm and so went to sleep.

When in the morning I woke up, I found every piece of furniture out of place, and no echidnas. They had managed during the night to lift up a loose board in the floor, and had escaped under the hotel. There unfortunately I had to leave them, since the space between the flooring of the hotel and the earth was too small for me to crawl in after them. Both myself and the proprietor of the hotel were much annoyed at this unfortunate ending of my adventure with echidnas, but for different reasons. He thought they would disturb the other guests in the hotel by shuffling and digging under the other bedrooms, and I was sorry not to be able to keep them and observe their interesting breeding habits. One deduction at least I was able to make from this adventure: that these comparatively small animals were able to push about large pieces of furniture. This they did, no doubt, with the strong digging muscles of their backs and shoulders.

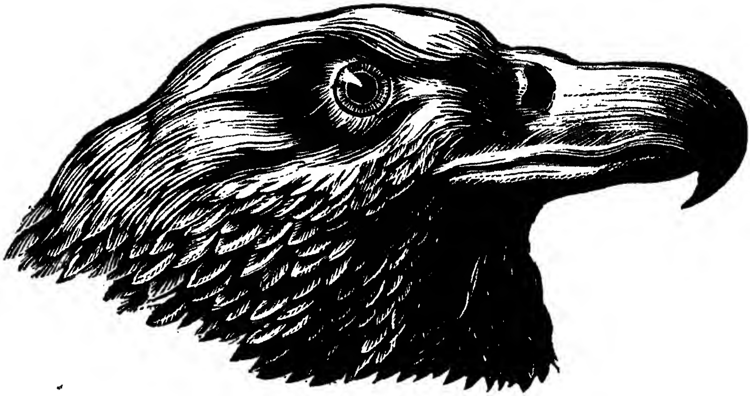
An allied and equally peculiar creature is the Ornithorhynchus, or Duck-billed Platypus. This animal is not found in Western Australia, but I have seen them in Tasmania, and they inhabit most of the rivers of eastern Australia. The platypus burrows in the river banks and swims in the water, and likes a dry and warm nesting place. For swimming it is provided with webbed feet. These webs, which extend beyond the length of the claws, can be withdrawn and folded under the foot when the animal is running or is using its claws for burrowing purposes. As a digger it is very expert. It has some sense-perception which enables it to be aware of the proximity of other burrows. It will most skilfully avoid breaking into these, whether these burrows are self-made or by others of the same species or by

creatures of different species, such as water rats or rabbits. When engaged in its burrowing operations it may chance to come near to these other tunnels, it will alter its course so as to avoid them. In making its own tunnel, it is most careful to conceal the way which leads to the underground nest. The burrow is long and winding, and will usually be provided with more than one false ending—a foot or so of soft worked earth which blocks the hole. The hole will, however, continue beyond this. Several of these false endings are found before the nest is reached. The defenceless young are in this way protected by what we call the instinct of the mother platypus for making false endings, which would turn back any predaceous creature that had penetrated far along her burrow.

The platypus, like the echidna, lays eggs. These are often produced in couples, and are attached to one another. They are laid in the nest and hatch into small, completely helpless creatures. The mother has no pouch, but holds the young to the teats by her flexible tail which bends round them and so holds them in position. The tail is a remarkable feature. It is broad and flat, and like the beaver's tail is of great use in swimming and diving. One of the most obviously remarkable things about the platypus is the duck-like beak, which is horny and broad and flat, and is used in much the same way as the duck uses its beak, for sifting out food from a watery medium. The food, which consists of insects, worms and freshwater crustaceans, is collected under water, and is held for a short while in the two pouches there are on each side of the mouth. When the animal rises to the surface it will grind up the creatures it has secured in its cheek pouches with the horny plates of its bill.

The fur on the Tasmanian specimens that I have seen is remarkably fine and thick, also rather greasy and well adapted to keeping the animal dry. The platypus is a great swimmer and diver, as swift in movement as an otter, which is saying a good deal, and can float on its back, in an amusing position, with tail and head raised well above the surface of the water. On the inner side of each hind leg there is a horny spur. This is hollow, and is connected with a gland which secretes a poisonous fluid. What this spur and poison are for is not known, but it is assumed that the spur is to be used for defence, though no case is known where the animal has used it for this purpose. The fluid has, however, been extracted from the gland and injected into a rat. The rat died shortly afterwards.

Both the echidna and the platypus are remarkable and interesting animals. They are considered to be the most primitive of all mammals, and are believed to form a link between reptiles and mammals. They have several reptilian characteristics, as, for example, the bony structures of their limb girdles, and the fact that they lay soft-shelled eggs. They are mammals in that they suckle their young, and the mother echidna resembles the marsupials in that she carries her young in a pouch. It is considered probable that both these animals are survivors from earlier types which have been exterminated elsewhere. How closely they represent those hypothetical, extinct types we cannot tell. The process of specialisation and devolution may have gone far in them, and they may now be very different from the archetypes from which they are derived. But, such as they are, they must stimulate our wonder at their strange combination of qualities, which combine primitive reptilian characteristics with those of mammals.



THE ELOQUENCE OF EYES

The eyeless worm in its search for a satisfactory environment is an opportunist in so far as it lacks vision and the judgment which comes with vision. Its sensitive snout feels a way, testing the different qualities of earth, these grains which are hard, and these which are softer, and these others which give a promise of decomposing leaves. It lives by trial and error, and in its darkness is devoid of understanding. Animals which have eyes possess with their function of sight an enhanced consciousness, and the judgment which follows their vision will often indicate a more direct method of attaining their ends than the acceptance of the easiest path—not always the shortest.

Compare with the worm the hawk or the eagle, which, sweeping in easy flight over mountains and plains, sees a whole countryside spread beneath. The bird can discriminate which district is dangerous, which likely to yield food; small signs are not lost; and the messages which the light brings to its brain are tokens of experiences both past and to come. The large and brilliant eyes of the eagle are to our own human scrutiny so remarkable that they carry at once a conviction of their great efficiency.

Once it was my misfortune to shoot an eagle—a deliberate mis-

fortune, for I had spent several days stalking the sea-eagles over the barren, brush-grown rocks of Bernier Island in Shark Bay. I had never succeeded in getting within range, for though the eagles in that remote place can have had little experience of men with guns, they were very shy. I had noticed, however, that often when I was bathing an eagle would come near and hover above me, and once it had swooped alarmingly close. I took my gun to the beach and, having taken off my clothes, lay down with it at my side. The eagle, as it had done before, came and hovered in curious regard of my nakedness. I shot, but did not kill it. It came fluttering down into some bushes not far distant. I then had to capture and kill the eagle—no easy task.

Although I was excited and my senses consequently deadened, they were not so deadened but that I must perceive the beauty of the eagle's eyes as they glared at me full of terror and indignation. Here was a beauty absolute and convincing; these eyes were adequate receptacles of the light which they were fashioned to receive; and as I watched the life fade in those marvellous orbs, I was ashamed that I should have shot this bird for a mere dinner.

All highly developed and efficient eyes are beautiful. The mosquito's, under a lens, are domes of many-coloured glass or crystal; their opalescent facets are set upon the larger portion of a sphere, and look out many ways. A dragonfly's eyes are even more remarkable, and their darker pigmentation gives to their massed, narrowed and deepened cups an iridescence ranging from pale green, through all the shades of blue, to black. How much the vision of such compound-eyed creatures differs from our own sight we cannot know; and though contrivances have been devised through which photographs have been taken through the compound eyes of insects, and though those photographs produce a picture, whether that picture is the same as is received by the consciousness of the insect, we cannot be sure. But what we can be sure of is that the compound eyes of insects are very efficient organs, and that their possessors see with them remarkably well. We have only to observe the dragonflies as they watch for and catch smaller insects to be sure of this. Their function is perfect, and the beauty of such eyes, though not so vivid and personal as that of an eagle's, is no less indicative of their light-receiving quality; and though so different, they are equally convincing as organs of an increasing and discriminating consciousness.

The simple eyes of the higher animals are subject to the most interesting forms of adaptation. Many of such adaptations to particular environment are shown by fishes. The eyes of fishes which live at great depths, and consequently in darkness, are usually large and well developed, that they may be competent to catch the faint lights from the phosphorescent creatures which live beyond the reach of sunlight. Some few of the creatures which live in the abysses of ocean are blind, but these are members of those species which habitually burrow beneath stones. Their eyes are vestigial and functionless, and the eyeballs are often collapsed. In other species, the eyes have completely disappeared, leaving no trace. There is a fish, living at a depth of 1,260 fathoms, which has its eyes covered with skin. This suggests that the organs, unable any longer to function in so prevailing a darkness, were of no value to their possessor and had, with the passing of generations, become invaded by tissues which under more normal conditions would be controlled and restrained by the co-ordinating dynamism of its life.

Blind fish are more commonly found in dark caves than in the depths of the sea. In the caves of Kentucky and Pennsylvania there are several species of completely blind animals. In these waters is utter darkness, there being no phosphorescent organs carried by their inhabitants. Those fish are also blind which live the whole of their lives in holes and crannies, as for example a small goby which lives in burrows made by a shrimp. The shrimp, which often emerges from its retreat, is not blind; but the goby, which never leaves the burrow, is blind.

One of the most interesting examples of adaptation amongst fishes is a little freshwater fish inhabiting the rivers of Central and South America. The eyes of these fishes (*Anableps*) are divided horizontally into upper and lower portions. The eyes are large. Projecting across the front part of the cornea is a pigmented band; the pupil is also divided by a corresponding partition of the iris, and the curvature of the lower half of the lens is more convex than the upper half. This horizontal division of the eyes corresponds exactly with the level of the water in which the fish swims, so that the upper portion of the eye is in the air and sees the objects which are above the water level, while the lower portion looks downward and can see those things which are under the water. These fish have a habit of swimming in schools on the surface of the rivers. They eat such things as they can

pick up on the surface, and are seldom seen to jump out of the water or to dive under it. When on rare occasions they do dive under, they have difficulty in keeping down, and soon come up again. It is interesting to notice that the eyes of these fish develop in their earlier stages in the normal manner, and that the peculiarity of the horizontal division is secondary. In the youngest embryos the eyes are simple, as in ordinary fishes; in later stages the iris develops lateral projections, and finally the cornea is divided by an horizontal band. The history of this development in the individual would appear to indicate the development of the race. The ancestral form of the *Anableps* would have, we would suppose, normal eyes; but since these fishes had the habit of swimming on the surface with their eyes half in and half out of water, they became gradually adapted to this condition. Such a history demonstrates an increase of variation as the direct result of external influence: the inheritance of acquired characteristics.

Another case of unusual adaptation amongst fishes is provided by a deep-sea fish from the Indian Ocean. The eyes are on the ends of long slender stalks, projecting from the sides of the head.

To have eyes upon stalks is no exceptional thing, though rare amongst fishes. Everyone has seen the common snail extend horns, and seen the eyes extruded at the very end of those long stalks. Many of the tropical crabs have their eyes on the ends of stalks. In some cases both eyes and stalks fit into little grooves on the crab's back and they can either lie in these grooves or can be raised up to an erect position. I have seen hundreds of such crabs walking on the beaches of the islands in Shark Bay. In the evenings they come out of their holes and walk about on the sands. Usually they have their eye-stalks erected, so that they can see the better, but if they are frightened by any sudden movement, they flip their eyes down into the prone position, where they fit into the grooves provided for them. A sudden movement will frighten a whole army of such crabs, and down will go all their eyes in a communal wink. Then in a few moments up will be raised the stalked eyes once more, and the crabs will scuttle off as fast as they can to a safer place.

Snakes' eyes appear to be always open, but are, in fact, always closed. The eyelids, which are in the lizards separate, have in the snakes become fused together and have become transparent, so that the snake can see through the closed lids. The lids are closed, and so

form a screen before the eyes, a protection to the organs of an animal which must, owing to its lack of limbs, move close to the earth and in the dust. There are some genera of lizards which show an interesting intermediary stage between the normal lidded condition, as shown in most lizards, and the closed, transparent eyelids of the snakes. These lizards, the skinks, have an enlarged lower lid which in some species is partially transparent. When the lids are closed, the lower lid covers the eye, protecting it, and yet the protected eye can see through the window in the lid. In other species of skinks, the edge of the lower eyelid is completely fused to the smaller upper eyelid. These lizards, like the snakes, cannot open their eyes, and like the snakes they can see through the transparent lids. The only difference in the adaptation is that in the snakes all trace of fusion between the lids has disappeared. By this we see that both the snakes and the lizards have met in the same way the problem presented by living close to the earth. An adequate device has been found to keep the dust out of their eyes.

Snakes and lizards are not the only creatures which have been troubled with this problem, though it is they who seem to have met it in the most efficient manner. Earth-burrowing mammals, such as the mole, instead of growing transparent lids and so shielding their eyes, have taken the less enterprising course of giving up trying to use their eyes, or only using them a very little. The European moles have small, vestigial eyes which appear to be almost if not quite functionless. They have no eyelids, and the eyes, which are very small, seem to sit upright amongst the fur, tiny black vesicles on a thin stalk. These eyes, it is assumed, have atrophied through long disuse; and certainly it appears that the mole when on the surface of the earth is quite blind. The Australian marsupial mole, which does not live in damp burrows like the European mole, but swims its way through dry sand just beneath the surface, has no eyes at all and no eyelids.

Besides the eagles and the hawks, there are many creatures which have highly developed and very beautiful eyes. All the ostrich tribe have large, liquid and intelligent eyes and are quick- and far-sighted. Of mammals perhaps the most remarkable of all eyes is the giraffe's: a dark and luminous pool, fringed with long black lashes; but a camel's run it very close. A horse's eye can also be very beautiful and full of expression; so too, in a very different way, can be a cat's;

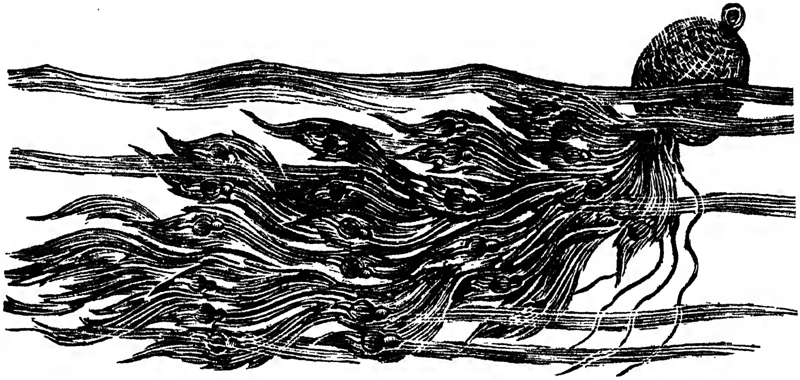
the cat's eye which can see in the dark, and whose pupil can close in the sunlight to the thinnest longitudinal streak.

The whale, though it is so enormous in bulk, has a small eye, no larger than that of a horse. Between the eyes, which are set far apart, one on each side of the head, is all the thickness of neck and body, which completely shuts off one field of vision from the other. The whale must constantly have two visual pictures presented to its consciousness. This must certainly be very puzzling, unless it possesses some co-ordinating process of which we know nothing. Such an animal would, without some such co-ordinating process, find it very difficult to adapt individual movement to two different and distinct pictures of the world. It may be suggested that the *Anableps* also has two different and distinct pictures, one above water and one under. Perhaps it does, but it is more probable that it regards either one or the other, at any particular time. The separate eyes operate in, and enclose, the same field of vision. The whale, on the other hand, must, all the time that its eyes are open, gaze in two *opposite* directions. It sees two separate worlds always separated by the thickness of its own body.

That eyes should be the most expressive of features is not strange when we consider that it is these organs which receive and register the light, and with the light the consciousness of the things which light illuminates. From this consciousness must come, if not at once, yet ultimately, judgment; and with judgment, memory and forethought. Eyes are in themselves expressions of personality, either of species or individuals, and as such are significant of what these personalities have, through the operating of their own functions, achieved. The possession of eyes marks in the biological world the difference between those who can see and judge, and those who must still progress through the mere opportunism of trial and error.

In both animals and men, eyes as organs of physical vision have probably reached their perfection; and amongst men, sight, the most highly prized of the senses, is taken for the symbol of yet further consciousness. We often speak of *vision*, meaning a supersensual perception, though in respect to such perception the majority of us feel ourselves to be blind, like the worm, to that light which must, with our increasing development, illuminate our consciousness. Like the worm we move by trial and error, as the crudest opportunists, seeking immediate advantage, and without the larger plan that vision

would give. Our poets and our seers, prophesying of supersensual illumination, are comparable to those primitive creatures whose pigment spots can but distinguish light from darkness. The objective universe of the spirit is as yet unknown to science; only the 'unscientific' philosophers have dared as yet to suggest its existence.



COMPOSITE ANIMALS

Amongst the simplest of living things are to be found organisms, compounded of separate living elements, which elements are able, in slightly different arrangements, to exist in other numerical associations, or as free-living individuals. Such a creature is *Pandorina*, a free-swimming colony of sixteen or sometimes of thirty-two cells, each with two flagella, or fine whip-like processes, an eye-spot, a nucleus and with chloroplasts, which are specially modified masses of protoplasm containing chlorophyl, by which the organism can take carbon dioxide from the air dissolved in water, and from this, in the presence of sunlight, form sugars and starch. Sixteen or thirty-two of such cells, enclosed in a cellulose envelope, form a single free-swimming *Pandorina*. In such a colony the flagella of the separate units are directed outwards, and are free to move in the surrounding water in which the colony lives.

Cells which are similar to the contributing units in *Pandorina* are also found living independently, and are named *Chlamydomonas*. *Chlamydomonas* is the same in form and structure as the cells in *Pandorina*. The only difference is that the *Chlamydomonas* unit is free and independent of other cells, and the elements in *Pandorina* are united in a containing wall to form a small colony.

Another arrangement of such cells is found in *Pleodorina*, where a larger number of individuals of the *Chlamydomonas* type are asso-

ciated within a containing cell-wall. Certain of these cells are capable of development into sexual individuals, some growing larger and constituting the female gametes, and some splitting up into a number of smaller male gametes. Others, on the other hand, remain small and do not split up, these are termed the somatic units, as opposed to the reproductive units. Another member of this group of organisms is *Volvox*. In a single *Volvox* colony are a large number of cells. The colony is sub-spherical in shape, with the individuals placed on the periphery with the flagella outwards, as in the other colonies. As in *Pleodorina*, individuals are specialised for different functions, the majority being small and somatic, and some few being developed into large female gametes, and some dividing up into a number of male microgametes. Besides reproducing sexually, *Volvox* reproduces asexually; certain individuals forming small daughter-colonies inside the parent colony.

The individual cells, all of the *Chlamydomonas* type, which form these colonies, are separated from each other, within the colony, by mucilage and by cell-walls, and are connected, one with another, by protoplasmic strands, traversing the mucilage and passing through the cell-walls. In these groups or cell associations we have an example of composite animals: individual cells associated together in groups, in which some of their numbers undergo special modifications, but others of which, and the majority, remain typical to the *Chlamydomonas* individual, which is free-swimming and independent of any association. Each separate member within the colony behaves in accordance with the ends beneficial to the life and well-being of the whole. What influence it is that controls this orientation towards a common end, and creates an harmonious differentiation within the colony, we do not know; we can but watch this process through which potentially free-living cells group themselves into larger more complex bodies at the sacrifice of their individual freedom. And as we watch, our imagination is stirred. Do we see, in the grouping of these individual cells, what is perhaps one of the simplest material manifestations of a universal impulse, one which finds other and more complex expression in all living things, and even perhaps in all things in the universe whether living or inanimate? And what, we are forced to ask, is the individual? Are we to consider the single free-swimming cell as the individual, or the complex colony with its sexual and asexual methods of reproduction?

Other more complicated organisms offer further examples of composite animals, made up of numerous units combined together to form a larger, more comprehensive whole, and one which contains all the contributing activities within its composite life. There are colonies of polyps which are related to the sea anemones, which grow upon branches, and which are connected one with another, and have a common tubular connection linking up all the separate units. Some of these units are typical polyps, rather like a simplified sea anemone, with tentacles and mouth. These function as eating individuals, catching small creatures that float by in the water, digesting them and passing on the products of digestion to the common stem. Other individuals do not make any effort to feed themselves, but derive their nourishment from the food procured by the active polyps. The latter are modified for reproduction. In some species the reproductive units are budded off in the form of small medusae, which medusae float free from the parent colony, produce male and female gametes, which are shed into the sea, and there unite to form fertilised eggs. The eggs, settling upon rocks or seaweed, form new branching stems, from which new colonies arise. In such creatures we find a number of individuals combining, in a branched, plant-like structure, to form a composite whole made up of a number of different parts, each of which displays many qualities of other free-living individuals. The polyps in such a colony as *Obelia* are comparable to the individual sea anemones, and behave in much the same way; the medusae are comparable to free-swimming jelly-fish: they are capable of feeding themselves, once they are detached from the parent stem, and they have also the power of sexual reproduction. Yet these partially manifesting individuals may well be considered as organs of the larger, containing colony—organs which in some cases are detached, and wander far in space from the creature of which they are essentially a part. Again we are presented with the question: what exactly does the word individual mean? I shall make no attempt at present to define this ambiguous term, but will first consider other cases of composite animals, and will then contrast the life of such creatures with the life of other colony-forming animals.

Colonies formed by yet more complicated associations of individual units are offered by other members of the *Coelenterate* order. The Portuguese men-of-war, which anyone who has sailed down the

west coast of Africa cannot have failed to observe, are groups of highly modified polyps, all living together, and functioning in their own peculiar way for the common benefit of the colony. Each Portuguese man-of-war consists of one large cap-shaped float, under which the other units are clustered. This cap-shaped float is itself a highly specialised polyp, and in its earlier stages is seen to resemble the typical archetype hydroid. Under the float are grouped the other members of the colony; these consist of two different types of tentacles, each developed and highly specialised from the primitive hydroid. The shorter tentacles are arranged under the edge of the float; the others, which are very much more elongated, hang down in a kind of drift-net to catch whatever comes their way in the form of eatable food. So strong are these catching-organs, or catching-individuals, that they are able to capture and hold a full grown mackerel. They can poison their prey with their stinging cells or nematocysts, and so virulent is this poison that it can endanger human life.

The tentacles, once they have secured and poisoned what they have caught, contract, bringing the food close under the float, into that region where those other individuals, specialised for sucking and digesting, are situated. These fasten upon the food with their many mouths and take the nourishment which supports the whole colony. The nutriment is passed along the tubes which connect every portion of this composite animal.

Besides the two separate forms of the predaceous individuals and the feeding individuals, there are other units specially modified for reproduction; these are situated well at the base of the feeding individuals, and in the most protected position possible under the bell-shaped float. These, of course, do nothing but produce the sexual cells, and are, like other sexual organs, parasitic on the organism. They are in this case fed by the food caught by the predaceous units and digested by the feeding units.

In this composite animal, we see how the different units all work together for a common end, the well-being of the colony. They are united into a whole and fed by a common liquid, and supported by a single umbrella-float, which is one of themselves, modified for this purpose. Compare such a united group of modified individuals with *Volvox* and we see that the differentiation has gone further, and that the component units are more specialised for their functions, though

they are yet united in one bodily whole. But compare it also with quite a different form of composite animal, a nest of termites.

Amongst the termites, we find a number of individual insects all working together for a common end. We find the queen termite and her mate, deeply hidden and well protected in the middle of the nest. The queen termite is highly specialised for the laying of eggs. Her abdomen is immensely swollen, and her short weak legs can hardly move her body. The king, her husband, is smaller than she is and more agile, but too large to get through the passages through which the workers can approach and leave the royal chamber. The workers are very much smaller, about ·4 cm. in length as compared with the queen's six to seven centimetres. They may be regarded as termites which have remained in the larval stage. They are usually blind and without reproductive organs. Their mandibles are well adapted for gnawing wood, and their chief function is to gather wood debris from outside the nest, to fill their intestines with it, and subsequently to use the ligneous paste thus produced for the manuring of fungus gardens, which are made in the lower and central portion of the nest. Their duties also include the building of the nest, the arching of the tunnels to keep their tender bodies protected from the ants, also the tending and feeding of the king and queen, and the transporting of the eggs. The workers are very numerous and well adapted for their many tasks.

The soldiers are larger than the workers, ·83 cm. long. They are more specialised and further removed from the sexual form. The soldier's head is hard and elongated, with sickle-shaped mandibles, ill-adapted for gnawing wood, but admirable weapons of offence or defence. The soldier's task is to defend the colony against ants, millipedes and other creatures, and its courage is proof against all trials. The soldier does not work at the collecting of wood-pulp nor at the cultivating of fungi.

In the termite colony the differing functions of the individuals are well marked: the king and queen, purely reproductive, the queen laying as many as 30,000 eggs a day; the workers are horticultural and mechanical, and the soldiers defensive; all are united by the guiding spirit of the colony, and each member performs its function with the regularity and precision of an organ, functioning within the body of the whole. If danger threatens, an instinctive response is made by the differently modified individuals, and this response is always

adequate to the occasion. Professor Bugnion in his book *The Origin of Instinct* describes the resistance made to ants by termites when a hole was artificially made in the termite nest.

'Some very agile ants scenting good fortune were soon on the spot. Forcing their way into the chamber, they seized the young larvae and stole away as quickly as possible, carrying their prey. As soon as they received warning, a multitude of soldier termites rushed up. Organising the defence, they arranged themselves in a circle all round the opening, opened their mandibles and offered resistance to the ants. The workers for their part lost not a moment in getting to work. They brought up little slabs of earth from the interior of the nest, moistened them with saliva, deposited them at the surface of the fungus bed, and began to construct a system of pillars. In half an hour's time a sort of lace pattern could be traced, formed out of damp earth. This lacework of earth was the first sign of an operculum which was to be propped up on the pillars, leaving no sign of an opening. A crack several millimetres broad, like a miniature trench, round the principal wall and the edges of the operculum, were occupied by the soldiers, which remained in circular formation all the time and opposed themselves unflinchingly to the invading ants. Remaining firmly at their posts, and protected by the trench in which they sheltered, they kept good watch until all danger was passed.'

This description shows clearly how the different types adapted themselves in a perfectly adequate manner to the emergency, each worker contributing to the complicated architectural task of building up a comparatively large operculum, and the soldiers assuming a military disposition competent to keep out the invaders. Such an instance is but one of many, and it is well known how that in hives of bees or nests of ants, an order, issued in some unknown way by the corporate body of the colony, can be taken up by each individual as though that individual unit were sensitively in touch and incorporated in the will of the whole. Again the question may be asked: what is an individual? The hive or nest, or the unit lives of which it is composed?

There are other aspects of this question, where the relation between corporate whole and the component parts are not so significantly defined. The starling when in the spring it takes to itself a mate and builds a nest, behaves very much as an individual bird. (Since the word individual is under question, I should say: what we are accustomed to think of as an individual bird.) In the autumn

when the large flocks are formed, then the starling behaves in some respects as though it were governed by some powerful and precise influence, which we can only speak of as the spirit of the flock. When the starlings are flying together in large numbers, each bird flies in accordance with the general flight of the flock. They do not copy each other, but often move instantaneously in the same way, every wing deflected or raised at the exact fraction of a second, as though the muscles and nerves were governed by some master nerve which was the attribute of the community, of that larger, psychic reality which was the starling flock. Then each bird behaves as an organ behaves, contributing to the movement and rhythm of the whole.

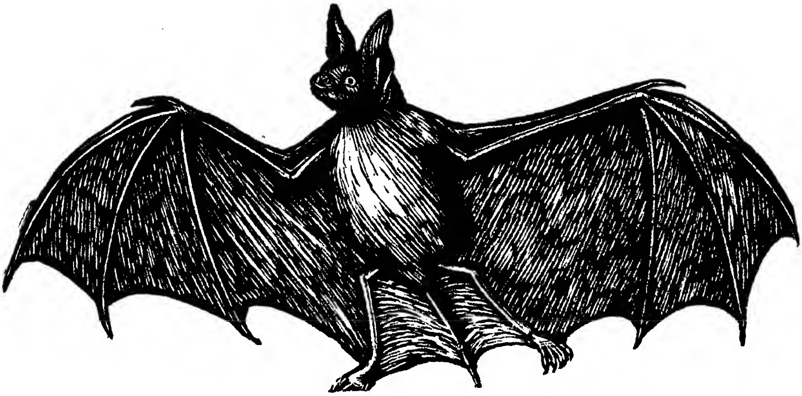
Not only in the movement of individual flocks, but in the movement of many flocks is this mysterious influence made manifest. Why should all the fishes of a certain species turn to migrate at the same time? Why should migrating birds follow each, according to its species, its line of flight, not by any means the shortest or most reasonable route to the desired locality? Is there not indicated by this behaviour some larger invisible reality binding these creatures together and making them one within the larger individuality of their species?

From these unanswered questions we are led further, unless imagination slumbers. If we have ever looked with contemplation at any animal—a dog, a cat or a duck—does not a prolonged scrutiny of its form, its nature and its specific sounds tell us of something beyond its material body? Do we in the dog which we know so well see an *individual* dog? He may have peculiarities of his own, but is not the essential quality of him a thing not pertaining particularly to himself, but to all dogs? He would seem rather, to that look of prolonged contemplation, to be but a partial expression of that dog-soul, inhabiting the bodies of all dogs, and imposing on them its larger individuality in habits of behaviour, which in the most strictly trained and domesticated dogs remain ineradicable. An animal shares with all others of its species those experiences which would constitute its destiny; in the things which happen to it, and in its reaction to those happenings, its species can be recognised. In this way it lacks that individuality which human beings claim to be their distinction and their most highly valued quality. The species may well be thought of as containing, what the separate units of the species lack, namely that unity, compounded of the attributes and characteristics of its many members, which defines an individual destiny.

Is then, we may ask as our last question, an individual that living creature whose destiny is within its own power to control, a creature which not only perceives as animals perceive, but knows and judges, and knowing and judging, can by its will separate itself from the objects which it perceives, and, to a certain extent, liberate itself from their influence? In so far as it can do this, it is free of the stresses and strains which constitute the ever-changing flux of the surrounding universe. If man is such a creature as this, then by that power he attains to a nature which can say: 'I, as subject, exist by the grace of my thought. Thought takes me out of myself, and relates me to objects. At the same time it separates me from them, inasmuch as I, as subject, am set over against the objects.'* If, and when he is able to say that, he attains his unique distinction amongst the animals. His thought then embraces himself and the rest of the world, and by that same act of thought, he determines himself an individual, in contrast to the objective world from which he is separated.

Should such be the conditions which distinguish individuality, how much do we as human units attain, and how much do we remain under the compulsion of the objects, and part of that unconscious, unknowing, unjudging composite creature, whose individuality, like the animal's, remains elsewhere, and which in past and present history constitutes the corporate man?

* *The Philosophy of Spiritual Activity,* Rudolf Steiner.



EXCEPTIONAL SENSIBILITIES

In early spring, towards the end of February, the Kentish Glory moth emerges from her cocoon, which has lain during the winter amongst dead leaves close to the ground. By short flights or by climbing she reaches the terminal twigs of silver birch trees. On these, after impregnation, she lays her eggs. As yet there is no sign of a leaf on these bare twigs, yet the moth, provided she is free to go where she will, seldom makes a mistake as to the tree on which she lays her eggs. Were she to do so and lay her eggs on any other kind of tree, or upon any portion of the tree but the twigs, then the young caterpillars when they emerged would not find the leaves on which to feed, and would not have the strength to walk so far as to find them. In order that these unseen, unknown offspring should survive, the mother moth must place her eggs in the right place, namely on the terminal twigs where leaves will be easy to find. The moth cannot know that the bare February twigs are going, long after she is dead, to put forth leaves, yet she invariably places her eggs in the right place. Some exceptional sensibility must communicate to her the rightness or wrongness of her environment in relation to her egg-laying. She must be sensitive to some radiations given off by the birch twigs. In the same way that the wireless apparatus is sensitive to certain etheric

waves, so it might seem possible that the moth is sensitive to other waves, of far different length no doubt from those received by the wireless set, but waves which will one day be measurable, which are sent out by the birch twigs.

The Kentish Glory is not exceptional in this capacity. Many other moths and butterflies, and many other kinds of insects also are able to select the right environment for their young without having any knowledge of what their young are going to be like, or of what their needs will be, and it is possible, if not definitely probable, that a great deal of what has hitherto been called instinct may be accounted for by a mechanism which is sensitive either to atmospheric or etheric waves. It is well known that the male moths of certain species will assemble from great distances to find the females. Henri Fabre carried out many carefully checked experiments on the Great Emperor moth and the Oak Egger. He records how hundreds of male moths came in the course of a few nights to visit one female. Neither the Emperor moth nor the Egger were noticeably common in his locality, yet these large numbers of males found their way from distant places to visit the females confined in his study. They must most certainly have received some kind of message. When the females were confined in an air-tight box, the males were not attracted, yet the message: 'Female moth of my species' which the males received was not in the nature of scent, for no strong covering scent could obscure it, and moreover it was found to travel up-wind and not down-wind, as would be the case of an air-borne scent. How this message is conveyed no one yet knows; we only know that it must exist, or the male moths would not respond as they do.

It has been supposed that the antennae of insects are sense organs of an exceptional kind. And anyone who has watched an insect, such as a locust, waving its long antennae in the air, is easily persuaded to believe that these sensitive-seeming organs must be capable of feeling and of communicating messages to their possessor. The fact that the male moths of such species as the Emperor and the Egger have larger and more dentated antennae than the females, would lead one to suppose that the males were provided with more sensitive organs, and for the purpose that they might seek out the more heavy-bodied and less mobile female. Fabre experimented by removing the antennae of the males, but came to no definite conclusion as to whether or not they were the organs that sensed the

locality of the female. It is known, however, that the antennae of insects always carry hairs, and that these hairs have in some cases an olfactory function. In such cases, if the antennae are removed or coated with wax, the sense of smell is largely destroyed. The Egger and the Emperor moths do not scent the female in the sense that we use the word. One scent can be obliterated by another, as witness that of a fox that runs through a flock of sheep; but in the case of the moth no amount of fumigation can keep the males from finding the females. They possess some extraordinary sensitiveness which is unknown to our perceptions, and can pick up not only the emanation given out by the female but the emanations which remain lingering about these places where she has lately been sitting. Fabre found that the moths would go more readily to those places where the female had been resting for some hours than to the female herself, when she had but recently taken up a new position.

The skin or the chitinous outer covering of many of the lower animals is in all probability sensitive in a way, or in ways, about which we know very little; not only the antennae of insects are distinguished as specialised centres of sensation, but many of the hairs with which their bodies are covered are highly sensitive, and some species of spiders are provided with curious emergences from the lower portion of the thorax, which are believed to be sense organs, though what their actual function is, is yet unknown.

The naked skin of higher animals or naked patches of skin are usually very sensitive. Frogs and toads are quickly aware of any coming change in climatic conditions, and even human skin, once it is given opportunity to function in the open air, develops many subtle sensibilities which are unknown to the normal clothed condition. The perceptivity of the stretched membranes which constitute the wings of a bat offers the most remarkable example of an unusual sensitiveness. The impact of currents of air upon the wing is sufficient to indicate to those acutely perceptive organs the nearness of any objects which may be contributing to the production of those currents. To demonstrate this extreme sensibility bats have been blinded, and then released in rooms where numbers of impedimenta in the form of wires have been stretched about and across the flying space. The bats although blinded and unable to see the wires or other objects, have been able to avoid flying into them by the sensitivity of their wings to the nearness of the objects. Even in that fraction of a

second as the wing approached, they have felt the presence of something nearby and the stimulus has been sufficient to enable them to so alter the stroke of the wing as to avoid the obstacle.

Another organ of sensitive perception about which little is definitely known is the tongue of a snake. Some naturalists, and W. H. Hudson amongst them, have maintained that the serpent's tongue is no sensitive organ, but is used either as a lure or a warning. To many others it seems to be an organ of sense, and so it appears to me. Ruskin has written: '. . . we've got to ask the scientific people what use a serpent has for its tongue, since it neither works it to talk with, or taste with, or hiss with, nor, as far as I know, to lick with, and least of all, to sting with—and yet, for people who do not know the creature, the little vibrating forked thread, flicked out of the mouth and back again, as quick as lightning, is the most striking part of the beast; but what is the use of it? Nearly every creature but a snake can do some sort of mischief with its tongue. A woman worries with it, a chameleon catches flies with it, a cat steals milk with it, a pholas digs holes in the rock with it, and a gnat digs holes in *us* with it; but the poor snake cannot do any manner of harm with it whatsoever; and what is *his* tongue for?'

For my own part, I have no doubt as to how I should answer Ruskin's question. I have watched many snakes both wild and in captivity, and I find it hard to understand how anyone who has closely observed the use of this organ can fail to see it as anything but a sensitive instrument feeling the air, *licking* the air, and each time that it withdraws into the mouth coming back with some message from the outside world. Hudson says that he has never seen a snake touch earth, rock or leaf, or anything whatsoever with its tongue. Consequently, he concludes, the tongue is not a tactile organ. He is wrong in saying that snakes never use their tongues for licking. On one occasion I have seen an Australian death adder licking a piece of dead grass stem and continuing to do so for some minutes. Why it was licking the grass I could not discover, but most definitely it was licking the grass with its finely-forked tongue, and appeared to find satisfaction in the act, for it returned after several short rests to continue those delicate and swift strokes with which its tongue seemed to caress the grass stem. And as a snake will on some occasions lick definite objects, so, I believe, it licks the atmosphere, feeling the quality of air as the bat's wing feels currents in the atmosphere. It turns its head

towards the object of its attention, then out will flash that forked thread of a tongue. As its interest or excitement becomes greater, or when danger threatens, the tongue becomes very active and the intervals between its extrusions will become shorter. Hudson in his essay on the serpent's tongue argues that this flashing in and out of the tongue is a necessary part of the creature's peculiar strangeness: 'The long, limbless body, lithely and mysteriously gliding on the surface; the glittering scales and curious mottlings, bright or lurid; the statuesque, arrowy head, sharp-cut and immovable; the round, lidless eyes, fixed and brilliant; the long, bifurcated tongue, shining black or crimson, with its fantastic flickering play before the close-shut, lipless mouth—that is the serpent, and probably no single detail in the fateful creature's appearance could be omitted and the effect of its presence on other animals be the same.' That is a wonderful and memorable picture, but it should be remembered that lizards, whose tongues are not so slender as a snake's, nor so deeply forked, are also used in exactly the same way, the tongue comes flicking in and out, feeling or licking the air. Lizards are not such 'fateful' or 'mysterious' creatures, and yet they have the same habit and, I believe, their tongues have in all probability the same function. They are neither used as warnings nor as lures, but as organs of sense, testing the atmosphere, though how precisely they function we do not know.

An organ of a quite different nature, yet probably possessing an exceptional kind of sensibility, is the lateral line possessed by most fishes. The skin is probably sensitive all over, since it is supplied with the terminations of sensory nerves; these are spindle-shaped bodies and are irregularly distributed all over the body, and in the mouth and pharynx form the organs of taste. The nerve terminations in the lateral line are similar to these, but are usually sunk beneath the skin and contained in grooves or in closed canals. In all cases they are developed on the surface of the body and subsequently enclosed by up-growings or overfoldings of skin. The lateral line is in most cases a tube which reaches from the base of the head from the auditory region along the side of the body to the root of the tail. Along the length of this tube there are at regular intervals openings to the exterior. The nerve endings are in the skin which lines the tube; they derive from a branch of the tenth cranial nerve, which runs parallel to the tube and sends small branches off to each sense organ. In some

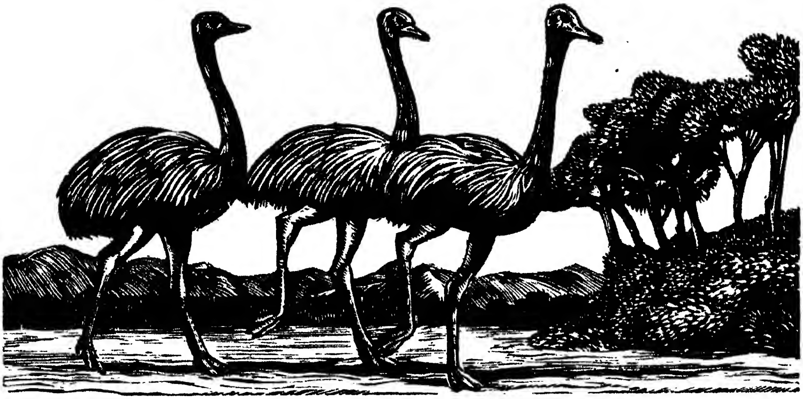
fishes this tube will have extensions which run over the head in branching lines; they radiate from a focus formed by the auditory organ, which may be regarded as an enlarged sense organ of the same system.

Although it has long been recognised that the lateral line constitutes a system of sense organs, it has been difficult and still remains difficult to know exactly how it functions. Experiments have been devised to try and find out what influence this system of organs has on the life of the fish. The nerves supplying the lateral line have been cut, and also those nerves supplying similar organs in the head. The behaviour of fishes thus operated on has then been compared with normal fishes. Very little difference was to be observed. Mr. G. H. Parker, who was carrying on these experiments, found that fishes whose lateral line nerves had been cut were not sensitive to certain low vibrations in the water which normal fishes responded to, and that the fishes that had been operated upon were in some other ways less sensitive. For example, if the surface of the water were blown upon and strong ripples produced, then the normal fish would go invariably to the bottom, whilst those with cut nerves would only sink a little way in the water. If objects were moved in the water close to the fish, in such a way that the fish could not see them, then the operated fishes were less sensitive than the normal to these disturbances. It would seem from this that the lateral line system of organs was for the perceiving of the movements of other fish or creatures moving in the water.

In a book dealing primarily with the peculiarities of animals, there is no space to deal at all adequately with all the extraordinary or unusual sensibilities which can occur in human beings. The testimony to such extraordinary sensibilities is often of an ill-substantiated nature, and lacks, on account of the very nature of its sensitivity, the controlled experiments which scientific exactitude demands. Of such experiences a large literature exists, under the headings of psychology, religious experience and under various forms of spiritualistic phenomena. Such experiences demand, with an increasing urgency, further open-minded investigation, but in this book there is no place for them, nor do I wish to recount the various stories of telepathic sympathy between dogs and their masters, or even those stories of the extraordinary homing-instincts of domesticated animals. One human experience, however, I will describe, as it bears directly on the

sensitivity of the human skin, and reveals a faculty which in civilised man is usually dormant and unsuspected.

An officer in the English army, fighting in East Africa during the Great War, gave me this account of his experiences. As a commander of a small patrol, it was his duty to keep in touch with other similar small bodies of men. This was often difficult as posts were far apart, and contact was only occasional in very wild country. The nights, when there was no moon, were very dark, and often when enemy patrols were suspected to be in the neighbourhood no light could be shown. On such dark nights, the men would listen to the lions roaring, and would notice that after a period of loud roaring, getting nearer and nearer, there would be silence. When the silence came, they believed that the lions were close to them, and were either stalking them or some other prey. During this silence, my informant and his companions would all suffer from severe shivering fits, which they could not control, and which they found very annoying, as suggesting the mark and sign of an uncontrollable fear. My friend had the idea that this humiliating shivering might be stopped by the wearing of a greatcoat. Whether because shivering is usually associated with cold he had this idea I do not know, but he and his companions were far from cold. The nights were extremely warm and the heavy coats very irksome. The wearing of coats had the desired effect, and my friend ordered that his men should always, on such occasions, wear theirs. Though they were hot and uncomfortable, they did not shiver. His belief, and I think it was a reasonable one, was that the almost naked body, clad only in thin shirt and pants, was sensitive to the nearness of the lions, and that shivering was an involuntary reaction. When the men wore their greatcoats, although they suffered from the great heat of the tropical nights, they were not affected by the unwelcome shivering, which appeared as a sign of fear, but was in reality a response to that sensitivity of the skin which apprehended the nearness of the lions.



DEGENERATE BIRDS

Though evolutionists find it difficult to point to any bird, living or extinct, which is provided with fore-limbs which may be considered as being in the process of developing towards wings, there is no question that there are many birds which possess vestigial or degenerating organs of flight. The theory put forward by evolutionists is as follows: the ancestors of birds were creatures which, at first, scuttled along the ground, and which used their fore-limbs to beat the air with, and so quicken their pace. Later, those which went the fastest were, owing to the action of natural selection, able to increase the advantage thus gained. In the course of generations they were able to take larger and larger hops, which, in time, resulted in glides, and finally in flight. This theory has no recorded facts to support it. Wings, when they are found, are found as wings, as complete and adequate mechanisms, and not as stumps or flappers. The stumps or flappers which are possessed by living or extinct birds mark various stages of devolution from earlier winged forms. Their possessors are losing or have lost the power of supporting themselves in the air. There are many instances of birds with degenerate wings.

An example of such degeneration in state of process is afforded by the South American logger-headed duck. This bird can fly when it is

young, but its wings are too small to support it when it grows older and heavier. It then uses them as auxiliary paddles to help it scuttle along over the surface of lake or pond.

The most remarkable and best-known group of flightless birds are, of course, the ostriches. These birds are well adapted for running over desert or steppe-land; their extreme length and heaviness of leg would alone, quite apart from their lack of pectoral muscles, make it impossible for them to fly. They use their wings spread out on either side when running; these help to give them balance, and often give the appearance of small sails spread before the wind. Darwin, in his *Journal of a Voyage round the World*, gives an account of the rheas or South American ostriches. These birds are to a certain extent parasitical, as Darwin expresses it, on each other, in that they lay eggs in each other's nests. In this respect they are like the cuckoos, in that they employ foster-parents for the incubation of their eggs and the the tending of their young. Like the cuckoos the hen birds lay their eggs at comparatively long intervals. The hen rhea has an interval of three days between the laying of the eggs. She lays in all from twenty to forty eggs (some authorities say as many as seventy). If she were to attempt to incubate these herself, those which were laid first would probably be addled before the latter ones were laid. She does not, however, try to incubate all her own eggs, nor does she lay them all in the same nest. Two or three females associate together at the nesting season, and place a large number of eggs in one nest, and they also seem to lay very carelessly and drop a certain number of eggs haphazardly in the neighbourhood. A male bird associates with each group of females, and he takes upon himself the task of incubation, and also he will collect a number of the chance-laid eggs and bring them to the nest. He will then sit upon the eggs and hatch them, and subsequently undertakes the care of the young chicks. The hen birds, which have not yet laid their full quota of eggs, will then move on, leaving the cock bird to his task of incubation, and will look out for and find another cock bird; they will make another nest, in which they will lay, and which in its turn will be taken charge of by the cock. In this way a fair proportion of the eggs will be incubated while they are still fresh.

This method of egg-laying and egg-incubation shows an extraordinary adaptation to the realities of the situation, namely the slow egg-laying propensities of the hens and the large number of eggs laid

by each hen. The numbers of the sexes are approximately equal. If we suppose that three hens club together in a group for the laying of eggs, then when they have between them laid the first forty eggs, they will move on, leaving a cock bird behind them to accomplish the incubation. Another nest is formed and another cock is found for the necessary task. By the time the third nest is made and a third cock is established upon the eggs, the hens will have laid their full quota of eggs. In this way an equal number of the sexes have been occupied in the business of reproduction.

But in actual life, the economy is not so perfect as it would appear in this suppositional case. Varying numbers of hens join together for their nest making. Sometimes they seem unable to find a cock when he is wanted. They are very careless in their egg-laying, sometimes laying in the nest, but often dropping their eggs at hazard. In this way a lot of eggs are wasted, although the cocks are known to collect these stray eggs and bring them to the nests.

The African ostriches, though larger and different in several respects from the South American rheas, have the same method of egg-laying and incubation. Both species demonstrate the same curious economy, which would appear to be determined by the fact that the females lay a large number of eggs at considerable intervals. The instinctive behaviour of both the cocks and the hens is in harmony with the conditions of their life; yet the harmony is by no means perfect, for, like the rheas, the hens are notoriously careless in the laying of their eggs, and often drop them too far distant from the nest for the cock to be able to collect them and bring them to the place of incubation.

Some naturalists have suggested that the stray eggs are later found by the young birds and eaten; this seems very improbable, as these stray eggs are usually found to be putrid and with unbroken shells.

The emu, a bird resembling the ostrich in many respects, has also degenerate wings, which are not able to be folded and which are altogether covered up by the hair-like feathers. Their nesting habits are similar to those of the rhea and the ostrich, in that the male bird collects and incubates the eggs. I have found emus in their native state to be very inquisitive and at the same time very shy birds. They are much hunted by the aborigines, who are very fond of their flesh when it has become sufficiently high for their strong palates, consequently the birds are hard to come near. I have found, however, that

when I have been sitting quite still in the bush (it is always a good plan to sit still if you want to see things) the emus have come to look at me. With a small piece of looking-glass I have managed to excite their natural curiosity to such an extent that by flashing the sunlight in the mirror and directing it in the neighbourhood of the emu, I have persuaded birds, on several different occasions, to come within a few feet. This experiment on their curiosity, besides being amusing and interesting, was also exciting. To see this large, imposing bird first make its appearance amongst the blue, feathery-leaved mulga bushes was always an event. I never actually *saw* one come into my field of vision, it was suddenly there, having approached so quietly that I had not noticed it. With the least possible movement I would flash the mirror. In a few moments the bird would come closer, and stretch out its long neck with the same enquiring expression as a hen. Another flash, and it would come nearer, nearer, nearer, until I could see the large bright eyes which look so intelligent under that flat, unintelligent forehead. The nictating membrane, a kind of shutter of blue skin which goes across the eye from time to time, I have always found fascinating to watch. It never fails to evoke in me an impression of the unexpected and bizarre, to be followed immediately by a return of that bright-eyed stare, and an as-you-were look, as of a conjurer completing his trick.

I have brought emus so near me by this device of the looking-glass, that I have been afraid that they might peck. When at last I have moved, how they have jumped with surprise and raced away for safety!

I have not myself ever been fortunate enough to find the eggs. Like the ostriches they are often careless in their laying, and odd, solitary eggs are frequently to be found lying about. Once I was in the bush with a native boy, and noticed the footmarks of an emu, and was foolish enough to point this out (it was not an easily seen mark) to the native. 'Emu,' he said with a grin, 'and twelve pickininy.' He held up hands and fingers to show the numbers.

After some questioning I found that his quick eyesight had seen in the dust the footmarks of young emus, and not only had seen these small marks, but had perceived that they were made by twelve *different* pairs of feet. These little feet had been moving to and fro, and up and down, and crossing each other's trails many times, yet the man said with confidence: twelve little ones. It seemed to me

unbelievable that he should be able to gauge the number. It was as though a man should look at the dust in an empty chicken run and should say how many had been there. I asked how far away they were. Not very far, he said. I told him to find them, and in a short while, by following the tracks, we came on a parent bird and, as he had said, twelve chicks.

The kiwi or apteryx of New Zealand has even less of wings than the emu, and its feathers are even more hair-like. It is smaller and lighter than an ordinary barn-yard fowl, yet it lays an egg weighing as much as fourteen and a half ounces, as against the fowl's average production of two and a quarter ounces. Seldom does the hen kiwi lay more than two, and even then the cock bird has considerable difficulty in covering them. These little creatures, which are now almost extinct on the larger islands, though they are protected and preserved on some of the small islands, have other qualities besides their absence of wings which indicate degeneration. They have a curious habit of heavy sleeping, and it is possible to pick them up and handle them without waking them. One must suppose that this habit could only have been possible in animals who had few enemies to harry them.

There are, or have been, a considerable number of flightless birds living or extinct in New Zealand. The islands are far distant from other and larger territories, and as a consequence of this remoteness, there are, with the exception of one small rat, no indigenous mammals. This absence of mammals may perhaps account for the number of birds that have taken to running on the land and have abandoned the habit of flight. Where there are no predaceous animals of the cat tribe, why should not a certain number of the birds become adapted to a terrestrial life? Whether there is any true cogency in so simple a question or not, the facts point to a replacement of mammalian quadrupeds by several species of large flightless birds. Various species of the genus *Dinornis*, some of which were as much as twelve feet high, roamed over the islands in large numbers, and only became extinct after the Maoris landed in New Zealand. Besides these large extinct species there are other smaller birds such as the kiwi; and besides such birds, which are obviously adapted to a running, scratching habit of life, there is a large parrot whose breast muscles are so poorly developed that its wings can only be used as side balancers and occasionally as gliders. This bird has taken to a night-time existence. During the day it remains hidden either in a hole in

the ground or amongst the roots of trees. Only in the night does it dare to come out and seek for its food. Another flightless bird of New Zealand is the Maori hen or weka rail. In general appearance it offers no peculiar features to suggest that it cannot fly. Its wings are of considerable size, but their quills are so soft that they are unable to hold the air.

Other extinct species besides the dinornis are the dodo and solitaire; both of these are of the pigeon tribe. The dodo, named from the Portuguese word *doudo*, which means simpleton, was found living in Mauritius when the island was first discovered. The dodo was a large, ungainly bird about the size of a turkey, and appears to have been unable to defend itself against either the men who invaded the island or the pigs which the men brought with them and which soon roamed at large in semi-wild herds. Within two hundred years of its discovery in 1507 it had ceased to exist. In the neighbouring island of Rodriguez an allied species, the solitaire, existed till about 1761, but its flightlessness, which before the discovery of the island had not been a serious disadvantage, now led to its extinction.

The auks and penguins are in a slightly different category from the birds already mentioned. They too are flightless, but their wings instead of being merely degenerate have become admirably adapted to swimming; as any one who visits the new penguin enclosure in the Zoological Gardens can see for himself. Penguins, in their long searching dives under water, use their wings as other birds use them in flight, and may be said to fly under water. But although they can fly under water, their wings are too narrow and small to be able to support their heavy bodies in the air. The razor-bills, which can often be seen in the sea round the English coasts, present an interesting half-way stage in this kind of wing development. Their wings, like the auks' and the penguins', are admirably adapted to swimming under water, but they are not so far modified for underwater work but that they can also fly in the air. The razor-bill has to beat its wings very swiftly to be able to sustain its weight in the air.

The great auk or gare-fowl, like the dodo and the solitaire, has become extinct. These birds, which inhabited Iceland and other northern islands including St. Kilda, were exterminated by men. They were hunted for their skins, their feathers and their flesh; their flesh being used not for human food but for the baiting of fishermen's hooks. As soon as there were signs that the species might become

extinct, the collectors and their agents finished the work of extermination. After having slaughtered these birds in their thousands without regard or without imagination, then, when they were extinct, men were prepared to pay fancy prices for their stuffed remains or for their hollow egg shells. As much as three hundred and thirty pounds was paid for a single egg shell! Some score or so of these relics still remain in museums, but the live bird, which lived happily enough until its defencelessness was discovered by men, is no more.

UNLIKELY NEIGHBOURS

There are animals which live in close association with each other and which yet seem to be the most unlikely neighbours. My attention was first drawn to this apparent neighbourliness of creatures which one would expect to be unneighbourly by the relation between foxes and rabbits at certain periods of the year. I had found a fox's earth with young cubs and had seen the vixen carrying a dead rabbit to her litter. That appeared natural enough, and I was glad that it was a rabbit and not one of my own chickens or ducks which lived not very far off. I was careful to avoid going too near the earth, for I did not want the foxes to move their quarters before I had had a good opportunity of looking at them. A few days later I went again. I approached carefully, keeping under cover. The time was about sunset, and out on a heath-covered slope lay one of the foxes. Close to her were several full-grown rabbits, running in short, rapid runs as is their habit, and sometimes giving little leaps. What at once appeared as remarkable was that they showed no sign of fear of the fox, but ran quite close to her, and she for her part watched them with a lazy kind of interest, and not as though they were her natural prey.

After a time the game that the rabbits were playing became faster,

and as they came more recklessly close to the fox, this seemed to overcome her mood of indolence. She jumped up and made a pass at one of the rabbits, but instead of trying to seize it, made a playful retreat, balanced for a moment on her hind legs, and then ran *away* from the rabbit, who quite understanding the nature of this gesture, ran after the fox; and when the fox crouched down leaped over her body; then went a short distance up the hillside and turned to thump an excited challenge with its hind leg.

In this manner they sported together in harmless playfulness while I watched. This game amongst the heather bushes and over the pale, close-nibbled grass, was within a bare hundred yards of the earth. On this occasion I saw no sign of the young foxes, which but two mornings before I had seen pulling at the dead rabbit their mother had brought them.

Why, I questioned, does the fox play with the rabbits and why are the rabbits not frightened of the fox?

This same story of foxes and rabbits playing together during the spring months, I have since heard from other people, and I have tried to puzzle out some theory to account for this strangeness.

W. H. Hudson in his book *A Naturalist in La Plata* tells of the vizcachas, large rodents about the size of a hare and great burrowers, which live on the Argentine pampas. These animals live communally in villages, each village being composed of about twelve to fifteen burrows. The earth thrown out from the burrows forms a considerable mound. In this mound of comparatively dry earth, raised some thirty inches above the surrounding plain, other animals come to live, and among these animals are foxes. A pair of foxes will establish themselves in a village by turning a pair of vizcachas out of their burrow and taking it for themselves. They do not kill the vizcachas, and after a time are accepted by the inhabitants of the village as permanent residents. They are quiet and unassuming in their demeanour, and often in the evenings sit on the mound in the company of the rightful owners. 'But in the spring,' Hudson writes, 'when the young vizcachas are large enough to leave their cells, then the fox makes them his prey; and if it is a bitch fox, with a family of eight or nine to provide for, she will grow so bold as to hunt her helpless quarry from hole to hole, and do battle with the old ones, and carry off the young in spite of them, so that all the young animals in the village are eventually destroyed. Often when the young foxes are

large enough to follow their mother, the whole family takes leave of the vizcachera where such cruel havoc has been made to settle in another, there to continue their depredations.'

Now it has seemed to me that the English fox may be behaving towards the rabbits in very much the same way as the South American fox is behaving towards the vizcachas. This theory is put forward tentatively and only as a suggestion. It would need much careful and checked observation to establish it in any way; it is, as I repeat, only a suggestion, which might account for the peculiar behaviour of the fox. Is it not possible that the English fox deliberately abstains from preying upon those rabbits that live in the immediate neighbourhood of its earth? If this were so, the rabbits that are left immune from attack could soon become accustomed to the foxes, and would, on occasions, play with them. The young rabbits, however, which are all the time being born will, as soon as they are old enough to run, be snapped up by the foxes. If there is anything in this idea, it is supported by the fact that only full-grown rabbits were to be seen playing on the hillside with the fox, and this at a time when young rabbits were exceedingly common in most other places.

The parent rabbits were no doubt too stupid to realise that their offspring were being preyed upon. What we cannot be so certain about is: is the fox wily enough to realise that old rabbits mean, in time, young rabbits, or is his behaviour merely one of those baffling automatisms which we meet with so frequently, and which are loosely classed under the description of instinctive action? Or is there perhaps some entirely different explanation, and is this another case of an association in antagonism such as we see in the rabbit and the stoat?

To return to the vizcachas, foxes are not the only other foreign inhabitants of their earthen villages. Birds of several species including a swallow and an owl nest in the bank-sides of the mound, and make smaller burrows into the sides of the excavations made by the vizcachas. These birds hop about or fly amongst the true architects and owners of the village, who take little notice of them. There are snakes also which habitually live in these mounds and burrows, and which appear to be, if not friendly to the other inhabitants, at least indifferent. Mice and rats and weasels and other mammals, such as the agouti, will use the vizcachas' villages rather than take the trouble to burrow for themselves. Insects of various kinds are here found

more frequently than elsewhere on the plains. They are attracted by the dryer, higher ground, and so each village mound of some sixteen to twenty feet across is the centre of mixed and various life, where different kinds of birds, snakes, insects and mammals all live together in what at first seems an unlikely association; each and all benefiting in some way by the activities of the vizcachas, who with their original industry have raised the earth above the surrounding moisture of the plain, and have made the burrows which their neighbours have either usurped or augmented to their own use.

While considering these associations of unlikely neighbours which occur in natural conditions, it is of interest to remember those associations or 'friendships' which so commonly occur amongst animals under domestication. As for example, friendships between horses and hens. I have known of several such, where a solitary horse in a field will seek out the company of a hen, and the hen responding to, or seeming to respond to the advance, whatever it may be, will separate herself from the other fowls and remain for the greater part of the day, and for many days on end, in the company of the horse. Such associations are common enough, and also between dogs and cats, cats and hens, lambs and dogs, and indeed there are a great variety of such friendships possible between any animals that are not too greatly separated.

Such relationships as these are easily enough observed in the artificial circumstance of domestication. They are, however, rarer in natural environment; but since it is of such common experience that such relations can be readily established in conditions created by men, and since they are also found, though far more rarely, in Nature, we are led to the conclusion that the power of instinctive aversion, or indifference between different species, is not so strong as our first wonder at such associations would lead us to suppose.

In another of his books Hudson tells of the strange modifications of instinct which take place in animals of different species which are brought up together in unusual domestic association. He tells of a pet lamb who forsook her mistress to live with a pack of dogs. All the dogs' habits were copied by the lamb. When the dogs lay sleeping in the sun, the lamb would lie amongst them with their heads pillowed on her sides; when they went hunting vizcachas, the lamb went too, and while the dogs dug at the burrows, the lamb frisked from hole to hole, pretending to be as interested as they. Hudson tells also of a

cat and rabbit, who because they were brought up together, even went so far in their sympathetic friendship as to copy each other's methods of eating: 'the cat would be seen laboriously gnawing at a cabbage stalk while the rabbit picked a bone'. There are cases too where foxes and foxhounds have lived together, and the hounds have even hunted the fox, but have never done him any injury, and two instances of otters reared from puppyhood with otterhounds. In one case the otter would go hunting with the hounds; in the second case the otter did not accompany the hounds, or was not allowed to go with them, but the hounds, although they hunted wild otters with all the zeal and fury natural to them, refused to bite or hurt them in any way. Their friendship with an otter had had a psychological effect on their otterhound natures.

WHERE FEAR IS NOT

Fear is usually considered to be the most universal, the most fundamental and often the most powerful of all the instincts. For the greater part of their lives most animals are subject to its influence, and the preservation of their existence is effected by constant regard for those dangers of which their fears bring them warning. At the time of mating and in the heat of personal conflict, the males of both birds and animals will become, in their preoccupation with each other, indifferent to dangers which at other times will fill them with alarm, and will so appear fearless. The maternal instinct to protect a young and helpless brood, though not banishing the fears, will overcome them, and the mother hen will run at the dog which threatens her chicks, with great gallantry; and, in the same way, the cows on the pampas of South America will turn on the dreaded pumas to defend their calves. But on neither of these occasions is fear far distant.

In most animals, fear is provoked by the unaccustomed. The domesticated cat which lives on easy terms with a large dog will none the less show every sign of fear when meeting a stranger dog, even though it is a small one. Anything strange, even to man, if its strangeness touches his imagination, is frightening. The swelling of a sponge in a pool of water has proved sufficient to frighten a whole tribe of Tibetans. Yet there are wild animals in which this sense of fear is only partial, and others in which it is wholly lacking.

The short-tailed field vole, which is so common in English hay

fields, and which in the springtime is so persistent in raiding our gardens for our newly planted peas, is an animal with a very incomplete sense of fear. I have often caught these little creatures in my hands, and though they make a fairly good attempt at getting away when chased through their native grass-tufts or through newly-cut hay-swathes, once they are caught, they seem part-tamed. Within half a minute of what must, from the vole's point of view, have been a violent hunt, the creature is sitting at its ease on the palm of my hand and eating the grains of corn or crumbs of bread that I offer. Its fear has completely gone. Even its desire to escape, which it showed so obviously a few moments ago, could not have been badly fear-stricken, or it could not now eat with such composure. It sits and nibbles and runs a little distance and again sits and nibbles; only when it is in the grass does it show symptoms of wanting to escape.

This absence of fear when in the presence of the unknown and the strange is to be observed in other British animals, but it is not nearly so well marked in this country as in some parts of the world. Charles Darwin in his description of the Galapagos Islands tells how the birds of that archipelago were singularly free from fear, and how slow they were at learning to avoid the dangers that the arrival of human beings had brought amongst them. He tells how that most of the birds of the islands, the mocking-thrushes, the finches, the wrens, tyrant flycatchers, doves and buzzards, could all be approached and struck down with sticks, and how that with the muzzle of his gun he pushed a hawk off a tree. One day while he was lying resting in the shade, and drinking from a pitcher made from the shell of a small tortoise, a mocking-thrush alighted on the edge of the shell which he held in his hand and began sipping at the water. Such examples of tameness were not by any means uncommon, and reports from earlier travellers say that the turtle-doves were then so tame (1684) that they would often alight on the heads and arms of the sailors, and could easily be captured alive. At the time of Darwin's visit (1832) they were not quite so tame as this, but appeared to have learnt very slowly that man is a dangerous animal. He records how that a boy on Charles Island, which had then been colonised six years, was able to strike down doves and finches with a switch.

From this tameness of the birds of recently populated archipelagos, he argues that fear is an acquired instinct, and suggests that animals and birds have to learn through long experience who are their en-

emies, and that mere strangeness is not sufficient to cause fear. In support, he instances the behaviour of other island-dwellers. The birds on the Falkland Islands were as tame as those of Galapagos. Snipe, geese, thrushes and buntings and hawks being easily approached by men, though these all showed fear of the native foxes. They had learnt to fear the foxes but had not yet, at that date, learnt to fear men. Early explorers of other out-of-the-way parts of the world tell the same story of the birds and animals being unafraid. Kerguelen Island which lies midway between Australia and the Cape, when first discovered, had on it many tame birds, and the two native birds of Tristan da Cunha were at first so tame as to be easily caught in the hands.

From this evidence, it would seem that the instinct of fear, which we accept as so universal and so fundamental, is an acquired characteristic. It is not, so it would appear, a thing easily learnt, but needs slowly to enter into the blood and experience of the species. Once it has entered and the lesson has been learnt there it remains, and is passed on to the inexperienced offspring. The fledgling sparrow fears men, though no man may have directly threatened it. The young of the wild rabbit are almost untameable. They have behind them generations of persecution. Yet the birds of the Galapagos Islands, though they see their brothers and sisters struck down, are slow to learn of the dangers which threaten.

In the same way, our own most deep-rooted fears have probably come to us through many generations of past experience. Some of these may be temporarily allayed, as are the inherited fears of the domesticated cat for the dog. Because she has been brought up with one particular dog from her first kitten-hood, she does not fear it, but when she sees a strange dog, then her racial experience is remembered in an instinctive reaction of hostility. It is so with us with our own fears and our hostilities; the acquired inheritance of the past is in them revived. But if we follow the argument a little further and accept the evidence of the island-dwelling faunas, then we will believe that our instinct of fear and distrust, which may seem so fundamental, is not part of our original nature, and should not take rank as of the same importance, as our instinct for love or for the protection of our children.

WORLDS WITHIN WORLDS

'Well may we affirm that every part of the world is habitable!' wrote Charles Darwin, and continued: 'Whether lakes of brine, or those subterranean ones hidden beneath volcanic mountains, warm mineral springs, the wide expanse and depth of ocean, the upper regions of the atmosphere and even the surface of perpetual snow—all support organic beings.' Having made this statement, so large in its implications, he allows the reader to contemplate it without further assistance, and turns with a serene simplicity to the continuation of his journal.

Before considering those special instances which Darwin mentions, it is convenient to take a passing glance at conditions prevailing in localities which are in no way peculiar, and which approximate to what we vaguely describe as normal. Those groups of natural forms, both plant and animal that inhabit there, will be seen to have a general inter-relatedness as, for example, the relatedness of common grass to the manure-forming bacteria, and to the many forms of animals, insects, birds, mammals, etc., that feed on it. These creatures accept the grass as part of their environment; yet they stray to other foods of other natures, and so are partially dependent on or give assistance to many and various species inhabiting the locality. A

general, ill-defined and wide inter-relationship is established between the many various groups and species that touch upon each other and sometimes intermingle, and which sometimes appear quite separate within that region where they occur side by side. That we may see more clearly that this is so, we have but to consider such common animals as mice or sparrows and their general relatedness to the world that they inhabit.

Mice, living as they do largely upon seeds, affect in no small measure the plant population of any district, and their indirect influence is even more potent, for preying on the grubs of humble-bees, they destroy the potential fertilisers of many kinds of flowers. Other insects, either beneficial or injurious, which are eaten by mice, exert their own influence on yet other species, and so further and further, in spreading ripples. Mice themselves provide food for cats, foxes, owls, hawks, snakes and other birds, mammals and reptiles. When mice become unusually common, the species that prey on them will gather from surrounding districts, and for the time the natural equilibrium of the local species will be altered. So it is also with other animals in such 'normal' localities, which support widely interrelated groups.

Yet if we look carefully at any one particular species in these 'normal' areas we will find that it is *directly* concerned with only a limited number of other species, and that these constitute for all practical purposes its world. A naturalist, in such a contemplation of any particular animal, will inevitably get, should he persevere in his task, an imaginative view of how the world must appear through the eyes and limited intelligence of the creature in question. This view, which by its nature must be largely subjective, must seem at first sight to have little scientific value; yet for the education of the faculties of the observer it will not prove useless, for he will discover that there are worlds within the world, and from the centre of each of such, a definite and peculiar idea looks out upon a universe which it creates, and by which it is conditioned. Where these conditions are specialised or in any way peculiar, these limited worlds, in which most unquestionably the animals do live and have their being, shrink and become clearly defined.

As a first example of such a world within the world consider those lakes where water has evaporated, leaving along their margins crystals of gypsum, and on their surface other crystals of sulphate of

soda. The mud beneath the water and the salt crystals is black and with a putrid smell, yet on the surface is a green and red frothy scum. This scum is found to be composed largely of infusoria and confervae, which are able to live in even so strong a salt solution and amidst the forming crystals. These infusoria and confervae form the diet of worms which burrow in the mud, and make possible the presence of these creatures. It is surprising that they can live in brine, yet they do, and so existing, they in turn form the diet of flamingoes which seem not to mind the saltiness of these worms. Darwin recounts that throughout Patagonia, in northern Chili and at the Galapagos Islands he met these birds wherever there were lakes of brine. The infusoria, living in the mud and finding their sustenance in such organic matter as the droppings of the flamingoes, the worms that feed on the infusoria, and the flamingoes, living on the worms; these form a little living world within itself, and each to the other are directly or indirectly important.

Another example of organisms dependent on each other and isolated in their dependence are the plants and animals which will inhabit a single tree in a tropical forest. Besides the main tree, which supports the liana and creepers which wind about its stem and hang from its branches, are the numerous plants which grow in the clefts and crevices of its bark; these include orchids, pitcher-plants, climbing arums and Tillandsias, curious hair-like plants which resemble lichens, but which are allied to the pitcher-plants; also numerous ferns, many of them of a creeping habit; and on the ferns and the other plants of the trees, grow many minute creeping mosses and liver-worts; parasites upon parasites. Many of these epiphytic plants have devices for collecting water. The pitcher-plants are the most remarkable in this respect, several of them containing in their specially modified rosettes of leaves small ponds, in which various animals and plants live, which are to be found nowhere else. Such various yet peculiar vegetation will support animals of diverse kinds, including snakes, lizards, frogs, birds and a host of insects, spiders, centipedes, etc., all of these living on one tree, and dependent on it for their support, and all of them adapted to that special form of existence. Not only does each tree form a little living world within itself, but each portion of a tree may be regarded as having its own special inhabitants. The tops of the trees, where the flowers and the majority of the leaves stretch up towards the light, have their own

groups of epiphytes and animal population. Lower levels can also be marked off in horizons, and on the bases of the stems and on the ground live different species of animals and plants. These same phenomena may be observed to be developed in a lesser degree in our pollard trees of Europe. Willows, alders and poplars will support many plants and their attendant animals in the bowls of humus which accumulate at the place where the trees have been lopped. Most of the plants will derive from seeds which are wind-borne, and so will show, to a certain extent, a natural selectiveness within the group.

The tropical forests throughout the world, no matter on what continent they flourish, present very much the same general features. In all cases the flowers and foliage are thrusting upward into the sunlight at the top of the supporting stems. Little of their luxuriance can be seen from below. In this mass of upper vegetation much of the animal life of the forest is localised. Here live many creatures which seldom or never descend to the ground. Frogs, snakes, lizards, monkeys, squirrels and numerous other species live in the tree-tops, and are specially adapted to that peculiar environment, and it is a remarkable fact that different localities and the species sharing those localities seem to have hit on different morphological adaptations to meet those conditions. In one district such widely diverse creatures as lizards and squirrels will have both developed a parachute apparatus —a stretched skin membrane between the fore- and hind-foot to enable them to take wide jumps from branch to branch. This modification will be general in that district. In another district, another device to meet the same ends and the same conditions will have been developed. Long and prehensile tails and arms will here be the dominating feature of the inhabiting species. Regarding such phenomena, one is almost tempted to believe in place daimons, which influence those creatures which live within their orbits, producing in one locality parachutes and in another prehensile tails. It is certainly a strange and enigmatic fact, and so far unexplained, that like conditions should produce in one locality one highly specialised development and in another locality another very different though equally highly specialised arrangement of organs, and that this specialisation should be shared by creatures belonging to quite different departments of the animal kingdom.

Other instances of animals sharing characteristics fitting them for

their peculiar environment are to be found in all parts of the world. Amongst the most noticeable are desert-dwelling creatures, all adapted to the resistance of drought, and living within the enclosed limits of their environment in a world within itself, in the same manner as the flamingoes and the worms and the infusoria make a complete cycle in relation to the salt lakes. Another such example of adaptation to a rigidly defined environment I have found in the fresh water contained within the neck of an extinct volcano. On the island of Koro, one of the islands of the Fijian group, and entirely volcanic in its structure, there is such a lake containing fresh water. It is reached after a considerable climb up the central core of the island. At about a third of the distance up towards the top of the mountain, one side of the neck of an ancient, now extinct, volcano has fallen away, leaving exposed the open neck in black, basalt rock. From the heights above, water descends in a cascade into the open neck, filling it and overflowing. A pool is formed of about twenty to thirty feet in diameter. The edges of this pool descend perpendicularly. I have bathed in it, and have felt how sheer and steeply they descend. The water is clear and warm on the surface, but a short distance down is very cold. Its depth, according to the natives and the white settlers living on the island, has never been plumbed, though lines have been lowered into it which have reached lower down than the level of the sea which surrounds the islands. Lines with fish-hooks have also been let down, and at a depth of several hundred feet, fish have been caught. These fish as they are pulled upwards in the water blow out their insides and burst, for, being adapted to live under the pressure of the deep column of water in the neck above them, they cannot adapt, on their rapid upward journey, to the lesser pressure of the upper layers of water. Their own compensating pressure from within remains the same, and so blows out their insides. Such fish must obviously live, and can only live, at a great depth, and in complete darkness. They are fresh-water fish, living in fresh water. Possibly the neck of the volcano, narrow as it is at the surface, may widen out lower down into a large lake. About this we cannot know, but we do know that the fish live in a restricted space of fresh water and at a considerable depth, and we must infer that they find something to live on. That something finds something else to live on, and so, in this restricted underground lake, living under an extreme pressure at a great depth and far from the light of the sun,

there exists a cycle of living creatures, a world within a world, even more restricted and confined than that other group which has established livelihood in the unlikely medium of brine-encrusted lakes.

SOME QUESTION MARKS

When Æsop wrote, telling stories of animals conversing as though they were men, he pictured common situations and drew obvious conclusions. At the present time with our more exact knowledge of Nature, we do not find such simple moral fables, but rather discover, in the lives of animals, peculiar patterns of behaviour; from these emerge vague hints and subtle reflections of human qualities; and although we may wish to look at animals objectively, we cannot, if we look with our whole intelligence, keep our eyes shut to the fact that our own growing perceptions alter the quality and nature of the universe that wè regard. We come to see that the subjective view *cannot*, by the very nature of consciousness, be altogether excluded. The patterns that we find in animal behaviour are far more subtle and elusive than any that Æsop devised, and in so far as our objective vision is clearer, so also must our perceiving consciousness become charged with a higher potential of subjective interpretation. This means that we introduce, whether we will or not, human ideals into the contemplation of the animal world, or, to quote Professor Whitehead's words, we can say: 'No biological science has been able to express itself apart from phraseology which is meaningless unless it refers to ideals proper to the organism in

question' (*Process and Reality*, page 116). In contradiction to such a view, the mechanistic hypothesis attempts to describe the world as containing existence without valuation, thereby setting up an abstract view of reality as ultimate truth. It takes the world as an independently objectively existing system, and ignores the part played by the perceiving mind. Many biologists and most philosophers have already abandoned this naïve realism, and have recognised that what we rather loosely describe as 'the world known to science' is no simple self-existing cosmos, independent of us who perceive it, nor yet a mere subjective creation of our minds, but is an unstable projection of the average psychic life.

Starting from such a viewpoint, which I believe to be the only rational one, we must of necessity find some portion of ourselves in the things which we regard, and so find at least one unifying principle in phenomena. From this objective-subjective view it is only a step to Henrik Steffens' assertion that animals are fixed ideas incarnate. Once the possibility of such an idea is admitted, correspondences of many kinds at once present themselves. The poetic and the imaginative are no longer excluded from the scientific vision, and the human response to the universe will no longer be departmentalised.

Such correspondences have already been hinted at in these essays. The relation between the rabbit and the stoat in which one member of the relationship acts in a way detrimental to itself, and in a way advantageous to its natural enemy, finds its parallel in many human associations, which in contradiction to the beneficial partnerships found between many dissimilar animals, might well be regarded as of disadvantage to one member at least of that relationship. We have but to consider in the light of this idea the many and various human associations with which we are all familiar to see that this is so. Our human trouble is that so many of these disadvantageous associations are not easily recognised as such.

Modern psychology has revealed within that wide range of human associations contained within the family many varieties of commensalism, parasitism and perhaps most common of all, the sheltering of one life within another, or the exploiting of one life by another, which does not always involve an actual parasitic relation. It is almost as though human psychological associations had been copied from some of the more bizarre partnerships that obscurely occur amongst lower animals. This resemblance may perhaps more cor-

rectly be expressed by saying that the same pattern is revealed in the one in psychological terms, in the other in physical.

There is a small fish called *Fierasfer* which inhabits waters where sea-cucumbers or Holothurians abound. Holothurians are degenerate animals which lie prone and motionless on submerged rocks, frequently on coral reefs. They are also found in deeper waters, and they live by taking sea water into their bodies, obtaining from it what nourishment they need, and expelling it again. Consequently they have within their bodies large water-spaces. The *Fierasfer* is a slender little fish of from four to seven inches long. Its body is nearly transparent and is only slightly pigmented. It tapers from head to tail and has dorsal and ventral fins extending the whole length of its body. In Nature it is found lurking inside the water-spaces in Holothurians, and is only found in those specimens taken from deep water. Those in shallow water are free from these uninvited guests.

In aquariums the association of these fishes with Holothurians has been carefully observed. With their noses the fish seek for the anal vents of the Holothurians. These openings are constantly being expanded and shut to allow for the flow of water from the respiratory cavities. Having found the opening, the fish bends its flexible body and inserts its tail. It then backs its way up into the Holothurian, and there, in the protected safety of the water-cavity, lives a great part of its time. It is not strictly parasitic on its host. It makes excursions to find its own food, and returns to its resting place. Several of these little fish will associate together within one host. They are uninvited guests, who exact lodging but no board.

Another fish, which is an uninvited guest, but of a different nature, is the *Remora*. This is provided with a sucking disk on the back, by which it can attach itself to larger fish such as sharks or to whales, porpoises and turtles. These do not feed on their hosts, but in all probability pick up scraps that their larger hosts let drop. The sucking disk is a modification of the dorsal fin, and it is a very efficient organ. On the east coast of Africa, the natives use the *Remora* for catching turtles. They fasten a metal ring round the base of the tail, take the *Remora* with them in a boat and when a turtle is sighted, throw the fish in the direction of the turtle. Its habit is to fasten on to something, and so it fastens on to the nearest object, namely the turtle. So strong is the sucker that the natives can pull the turtle thus captured to the boat.

Other creatures of a quite different nature, but which evoke questions difficult to answer, are the various insects which infest the dead mulga bushes in the Australian bush. On the living bushes are to be found the usual population of caterpillars, beetles, stick-insects, cockroaches, etc., but the dead bushes would seem to attract each its own particular form of animal life. Some of these dead mulga bushes I have found to be covered, literally covered with hundreds of ticks, and this, when there were no other ticks visible in the neighbourhood. The ticks hang on the dead branches by two of their eight legs. The other legs are stretched out, in the hope, usually a vain hope, that some blood-possessing creature may pass by. At the least touch the ticks loosen their hold, and once in contact with living flesh attempt to suck blood. As they hung on the trees they were flat and utterly emaciated, only their legs showed any sign of life. On the dead bushes they hung until they died, and after their death they would still cling there, hundreds of starved corpses on a withered bush. Why they should be there congregated in so unpromising a place I could never imagine.

Sometimes it would be a host of mosquitoes that took possession of a dead bush; there they would sit like a black fur upon the branches. Sometimes butterflies would gather on other dead mulga, the brilliant metallic, blue-winged butterflies of north-western Australia, or the dark hairstreak butterflies. These insects would also flutter around living bushes, but never in such numbers as round a dead bush, and there too in their hundreds they would sleep in the evenings. It may be objected that the ticks, the mosquitoes and the butterflies were on the live bushes too, but not so easily seen. It may be there were a few, but the large gatherings were always on the dead bushes, for which they seemed to have a particular affinity. There was no doubt that they preferred the dead bushes, and in the case of ticks, they lived and died there without a morsel of food.

Outside the range of recorded facts and checked observations, there lies a large land of folk-lore concerning animals and their relations to men. A great many of such folk-lore stories are obviously false, but there are others, which, incredible as they may seem at the first sight, may have some elements of truth in them, or may be indeed true. I will give but one instance of such a folk story, and will add to it the experience of a modern practising psychologist. The experience does not indeed confirm the truth of the tale, but it may, in

the view of some readers at any rate, give it a significance, and leave them with an open mind with regard to so obscure a subject.

There is a tradition in Scandinavian countries that magpies are badly affected towards certain individuals. There are believed to be people who are under a kind of spell in relation to these birds. This spell may be inherent and suddenly make itself manifest, or it may be deliberately put upon one individual by another. People suffering under this spell are attacked by magpies on all occasions on which they show themselves in the open, and they consequently suffer from an extreme fear and horror of these birds. There are stories of women who have lived for years inside their houses, behind drawn blinds, rather than risk any sight or contact with these ill omens.

Such a story as this may well be considered a mere fairy tale, and what place has it in a book which purports to deal with facts? What follows is, however, a recorded fact, and those psychologists who have had but occasional glimpses into the obscure places of the human soul will not find it so very surprising. A well-known psychologist was treating a patient who was suffering from an extreme phobia of birds. This woman complained that she was constantly attacked by birds, and in particular by blackbirds. The doctor having heard all her story and fully realising the reality of her fear, gently suggested to her that these birds that she maintained attacked her might in reality be subjective hallucinations. The woman was intelligent enough to realise that this indeed might be so, although her own belief was strong that the birds were actual birds which flew at her out of the hedges.

During the summer when the weather was fine, the doctor would sometimes receive his patients in a summer-house in his garden. On the first occasion that he took this particular patient to the summer-house, they were walking side by side, when a blackbird flew screaming at the woman and fastened with its claws on her blouse. She screamed and fainted. The doctor brushed aside the blackbird and supported the unconscious woman to the summer-house. As soon as she regained consciousness, she asked: 'Was that a real one, or a subjective illusion?' The doctor was forced to admit that in this case it was real. Here was indeed an animal metaphor fluttering out of the realm of symbols into the actual.

If, with Henrik Steffens, we ever come to regard animals as fixed ideas incarnate, then such associations of symbiosis as are instanced

by the relation between medusae and fish or between polyp and crustaceans, as described in an earlier chapter of this book; such relationships will not then seem quite so mysterious and unrelated. Commensal partnerships, and such odd associations as that between the *Fierasfer* and Holothurians, even the behaviour of blood-sucking ticks, dying in their hundreds of starvation on long defunct mulga bushes, and even also such antibiotic affinities as those of the rabbit and the stoat and the lady and the blackbird; these will then not appear to us merely as the odd hazards of chance, but rather as intimations of things which for their greater part escape our sensual experience, but which to an increasing consciousness may yield their secrets.